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THE CAMBRIDGE EXPEDITION TO VATNAJÖKULL, 1932:

A paper read at the Evening Meeting of the Society on 9 January 1933, by

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History of the Area

VATNAJÖKULL, the largest ice-cap in Europe, lies in the south-east corner of Iceland and covers an area of approximately 3400 square miles, or rather more than one-tenth of the total area of the island. Its greatest length from east to west is some 90 miles, and greatest breadth from north to south about 65 miles.

Although the Icelandic glaciers far exceed in size those of the European mainland, the history of their investigation is very limited, and the knowledge we possess at present is largely due to the Icelander Thorvaldur Thoroddsen, who travelled extensively throughout the country from 1881 to 1898. His published[1] work contains the most complete description so far of the island and its glacial conditions, but, despite the fact that the study of Icelandic glaciers is chiefly connected with Vatnajökull, our knowledge of this area is still very limited. While the general form and position of the ice-cap are known, the only detailed maps in existence are those of the Danish General Staff, on the scale of 1 : 50,000, of its southern edge. The western and north-eastern edges are still practically unexplored. A rough sketch-map of the Kverkfjöll region was made by Max Trautz in 1912, with astronomical observations to fix the position of the edge of the ice.[2] Practically nothing is known of its north-eastern corner, though a journey was made by F. W. W. Howell in 1896, and described in a paper to the British Association, which has unfortunately been lost, and only a very brief summary of it remains.[3] A map

[1] Th. Thoroddsen, "Island, Grundriss der Geographie und Geologie," *Petermanns Mitteilungen*, Ergänzungsheft, 1905, Nr. 152, and 1906, Nr. 153; also "An Account of the Physical Geography of Iceland, 1914," in 'The Botany of Iceland,' ed. by L. K. Rosenvinge and E. Warming, vol. i. *London: John Wheldon & Co.* 1912–18.

[2] M. Trautz, "Am Nordrand des Vatnajökull im Hochland von Island," *Petermanns Mitteilungen*, 65 (1919), 121–126, 223–229.

[3] F. W. W. Howell, "The Northern Glaciers of Vatnajökull, Iceland." Rept. 66, Brit. Assoc., 1896, p. 859.

summarizing the work of all previous expeditions to the centre of the ice-cap by H. Wadell[1] is of variable accuracy over the part we traversed.

Before this year the ice-cap itself had been crossed five times, but none of these expeditions had been organized on a large enough scale to allow any length of time to be spent in one place, and, consequently, the scientific results were greatly reduced. The first crossing was made in 1875, after two unsuccessful attempts by an Englishman, W. L. Watts, who succeeded in crossing Vatnajökull in its western part, in twelve days from south to north. He was accompanied by five Icelanders, and appears to have encountered very great difficulties with deep snow, fog, and strong winds.[2] Twenty-nine years later, in 1904, the ice-cap was again traversed by two Englishmen, J. H. Wigner and T. S. Muir, who sledged from north-east to south-west, and came down from the ice after covering 150 miles in twenty-six days. The chief result of this journey was the dissipation of the old idea of volcanoes in the neighbourhood of Grænalon, an ice-dammed lake in the north-western part of Skeiðarárjökull.[3]

In June 1912 Vatnajökull was crossed once more, this time from north to south and back again, by the Dane, J. P. Koch. He took with him fourteen ponies, which he wished to try out with a view to using them in Greenland, and made a rapid crossing from Kverkfjöll to Esjufjöll in only two days and nights.[4]

In 1919 two Swedes, H. Wadell and E. Ygberg, made an expedition to the central part of Vatnajökull with the object of finding the cause of the *jökullaup*, or sudden melting of the ice due to volcanic eruptions beneath the surface in the north-west part of Skeiðarárjökull. Important glaciological observations were made, and they succeeded in locating a huge crater basin in the ice, which solved the problem of those terrible floods which have periodically overwhelmed the country to the south.[1] Another crossing of the ice-cap was made in 1926 by four Icelanders, who took a sledge from Svinafellsjökull to Dyngjujökull, but there is no written account of this journey.

The 1932 Expedition

The Cambridge Expedition to Iceland this year was undertaken with two main objects: to try and ascertain the thickness of the ice of Vatnajökull, and to carry out an ecological survey of representative areas, both in the desert region to the north of the ice and the coastal belt on the south. It was hoped that this investigation would be of interest in linking up the work of the Oxford Expeditions to Spitsbergen, Greenland, and Lapland with what we are beginning to know of animal and plant communities in the British Islands.

It was obvious that for an expedition to make the best of the uncertain conditions it must be organized on a scale larger than anything which had been hitherto undertaken. By using the ordinary methods of travel it is possible to spend only two or three days in central Iceland, as there is no grass for the ponies to eat, and the expense of carrying fodder would be out of all proportion

[1] H. Wadell, "Some Observations from the Greatest Glacial Area in Iceland," *Geografiska Annaler*, 2 (1920), 300–323.

[2] W. L. Watts, 'Across the Vatnajökull.' London, 1876.

[3] J. H. Wigner, "The Vatnajökull traversed from North-East to South-West," *Alpine Journal*, 22 (1905), 436–448.

[4] J. P. Koch, "Den Danske Exspedition til Dronning Louises Land og tvaesover Nordgrönlands Inlandsis, 1912–1913," *G. Tidskrift*, Hefte VII (1912), 257–264.

to the results. We therefore decided to reach the central district with sledges across the ice-cap from Heinabergsjökull, taking enough food to stay on its northern edge for at least a fortnight, and thus completely avoiding the difficult problem of maintaining a line of communication with the farms farther north.

The expedition consisted of the following members: F. W. Anderson (geologist and zoologist), University College, Southampton; J. A. Beckett (surveyor), Sidney Sussex, Cambridge; P. Falk (botanist), King's; W. L. S. Fleming (geologist), Trinity Hall; W. V. Lewis (seismologist and surveyor), Caius; and B. B. Roberts (ornithologist), Emmanuel, leader.

Grants were received from this Society and the Royal Society which enabled us to obtain a geophysical seismograph for sounding the ice. Several colleges in Cambridge, and the Worts Fund, assisted with smaller contributions. The total cost of the expedition (excluding the seismic apparatus) was £472. We should like to record here our very sincere thanks to Professor Debenham and his assistant, Miss Creswick, without whose help and advice the expedition could never have left England; to Messrs. Pickering and Haldane's Steam Trawling Co., Ltd., who afforded us our outward passages to Iceland; to Commander F. W. Hawkridge, who made this possible; and to the many other firms and individuals who assisted us so generously. Special mention should be made of Cadbury Bros. and Bovril Ltd., who presented provisions. The organization of the expedition was greatly facilitated by the use of a room at the Scott Polar Research Institute.

As regards equipment we took two three-man ridge tents with sleeve entrances, and two 11-foot Norwegian sledges fitted with steel runners 0·02 inches thick. The food rations were based upon those used by Watkins during the British Arctic Air Route Expedition, but were modified for the different conditions. It appears to be worth noting that we lived for seven weeks on 26 oz. a day, viz. 6 oz. of biscuit, 8 oz. Bovril pemmican, 4 oz. "Anchor" butter, 4 oz. Cadbury's chocolate, 4 oz. sugar. Besides this we had Bournville cocoa to drink twice a day, and Horlick's Malted Milk Tablets on special occasions. We found that this ration contained sufficient nutriment, but did not entirely satisfy the desire for food, and it would have been preferable had we substituted something more permanent for a small part of the pemmican ration.

The expedition sailed from Hull on June 22 on board the steam trawler *Lord Balfour of Burleigh*, and landed at Hornafjörður in the south-east of Iceland four days later. Travelling by trawler saved considerable expense, and was well worth while in spite of the minor discomforts involved. We had, for instance, one bunk between the six of us, and that had to be shared with the skipper as well. The weather during the voyage was unpleasant, but during the finer intervals we passed the time by practising knots and revolver shooting at a very agile tin suspended from the mast-head.

By previous arrangement a small motor-boat came out to the entrance of the fjord in answer to our signals on the siren, and took us and our baggage to the small quay at Höfn, inside the fjord. The transference of our equipment in a rough sea to this small boat gave us several anxious moments, but finally everything was safely landed, to the intense interest of the inhabitants. At

this point Þorbergur Þorleifsson, our interpreter, who was to guide us for the first 20 miles of the journey up to the ice-cap, arrived. He had succeeded in collecting together twenty-eight ponies for us, and we spent the next two days repacking all our gear into Venesta cases each holding 60 lb.

We left Höfn on June 27 in an ancient Chevrolet which helped us over the first 3 miles of our journey as far as the edge of the fjord where the road ends. Here we transferred all our baggage to the pack ponies. Each of these carried two of the boxes slung on either side of the saddle. One of them carrying our two 11-foot sledges was almost entirely hidden beneath its load, and caused great amusement at the farms we passed on the way. Our cavalcade of ponies was a long one, each animal being tied by a short length of rope to the tail of the one in front. Each man led a string of four to six ponies.

The plains of the south coast are traversed by a large number of rivers of distributory pattern, constantly changing their course; and at each farm our party was joined by the local farmer to show us the best way across the rivers in his particular district. Some of them were as much as 4 feet deep and very swift: the sea in Hornafjörður itself took one and a half hours to cross. After this the next 20 miles was one long succession of rivers. Oilskins and rubber boots kept out most of the water, and are absolutely essential for a journey along this coast.

At Kálfafellsstaður we were met by an Icelander called Skarphjeðinn Gisláson, who had prospected the best pony route through the mountains to the edge of the ice, and who led the way up to the ice at a height of 2380 feet. Our route led up Staðardalur, a valley on the western side of Heinabergsjökull. It was the only practicable way for ponies to get up to the high ice on the southern border of Vatnajökull, and the Icelanders have now called it Kambryggjuvegur, though few people would connect this with Cambridge after which it is named. The ascent took ten hours to the top of Heinabergsjökull, and here we pitched our first camp on the ice.

At this point the Icelanders returned with the ponies, leaving us to continue the journey with sledges and on skis. The ponies had managed their loads extremely well, and proved reliable both on steep scree slopes and in the rivers; and although their hire proved expensive, they were an essential to the success of the first part of our journey. They even exceeded what we had been led to expect from the eulogies of other Icelandic travellers.

From our first camp the surface rose in a series of undulating hills of ice stretching northwards as far as we could see. We ascended a small snow-peak near the camp from which we were able to choose a suitable place in the upper *névé* region of Heinabergsjökull to begin the seismic sounding experiments; but unfortunately these had to be abandoned owing to a mechanical breakdown in the instrument, which we therefore decided to leave behind and collect on our return.

We started across the ice-cap early in the morning of July 1, each of the sledges being loaded with 690 lb. of food and equipment. For hauling the sledges, harness of Shackleton type was employed provided with a 10-foot rope and eye-splice which fastened into a toggle attached to the front of the sledge. The temperature was well above freezing and the surface very soft. This, with the upward slope, made man-hauling distinctly arduous, and we

only succeeded in covering 2 miles on our first day. By this time however we were clear of the crevassed area, and the outlook for the future seemed more promising.

Before this the weather had treated us kindly, but the next day it broke, and a thick fog set in lasting continuously for ten days. During the first five of these a blizzard forced us to lie in our sleeping bags and pass the time by talking and singing, the monotony of these days being only relieved at meal-times. On the night of July 3 the gale increased and there was considerable speculation as to the probable fate of the tent and its contents should the guy-ropes break. Most of this time the temperature was in the neighbourhood of freezing-point, but very seldom below. The wet caused a considerable lowering of the ground surface all round the tents, which were left standing on miniature plateaux nearly 2 feet above the surrounding surface. The effect of this was to remove all the snow we had piled on the snow-flaps of the tents which consequently collapsed in a sudden gust; but we succeeded in re-erecting them, and by constantly piling on more snow we were able to counteract the thaw. On July 5 the wind died down; the rain and snow ceased, and we crawled out of our tents and started striking camp for another move northwards. The wetness and unpleasing nature of this place earned for it the name of Camp Driblet, and we were glad to leave it behind.

We continued ascending and pitched Camp Three the next night at a height of 3700 feet; in just over 5 miles we had risen 1100 feet; and the following day we rose a further 700 feet, where we made our highest camp, 4400 feet above sea-level. The section across Vatnajökull (see folding map) shows clearly this steep rise on the southern edge of the ice-cap and the gentle slope towards Brúarjökull on the north, where the surface falls less than 700 feet in nearly 20 miles. The highest part of the eastern section of the ice-cap does not appear to exceed 5000 feet.

After this we decided to try sledging by night to take advantage of the slightly colder temperature, but still the surface was very soft, and it obstinately refused to freeze. The routine varied but little from day to day; most of the time we were in a thick fog, and in order to keep our compass-bearing we followed one another, the second sledge shouting to the first if their tracks deviated from the straight course. It was our first experience of the strange sensation of seeing no horizon, and the snow in the foreground merging into the sky without any break. Under these circumstances sledging is a monotonous occupation and one is fatigued rather by boredom than physical weariness. Owing to the heavy rain and fog during the greater part of the journey, it was necessary to pull in oilskins and sou'westers—unusual clothing for sledging.

For the next few days the surface was comparatively good. One day the fog cleared for a few hours, and a period of intense photographic activity ensued, as we felt this might be our only chance. We also took the opportunity to hang out our wet things to dry, but woke up a few hours later to find them wetter than before and that the fog had descended upon us again. During this period of sunshine a fine panoramic view of the mountains to the north gradually opened up. Every mile the view became more beautiful as the shadowy images took definite shape; and as peak after peak came into view argument raged fiercely as to their identity; but the map is so inaccurate that we were unable to

come to any conclusions at all until some days later. Our first sight of Kverkfjöll, the region we were making for, showed a great mountainous ridge some 6 or 8 miles long, facing south-south-west, and rising more than 2000 feet above the general level of Vatnajökull. The fact that we were getting nearer the northern edge of the ice was very plainly indicated by the steady increase of volcanic dust. It was impossible to get drinkable water without digging out snow from well below the surface, and this difficulty gradually increased as we got farther north. The result of this increased dust was a more rapid rate of thaw, and the snow quickly became more and more hummocky, like the surface of a choppy sea.

At a height of 3500 feet, some 10 miles from the northern edge of the ice, we encountered extensive thaw streams and pools of slush. The surface was frozen, but underneath there was a foot or two of semi-frozen slush, so that at every step one broke through the crust and sank in up to the knees until further advance became impossible. There was nothing to do but to return some distance along our route and then strike west, threading our way along the maze of comparatively hard snow between the pools.

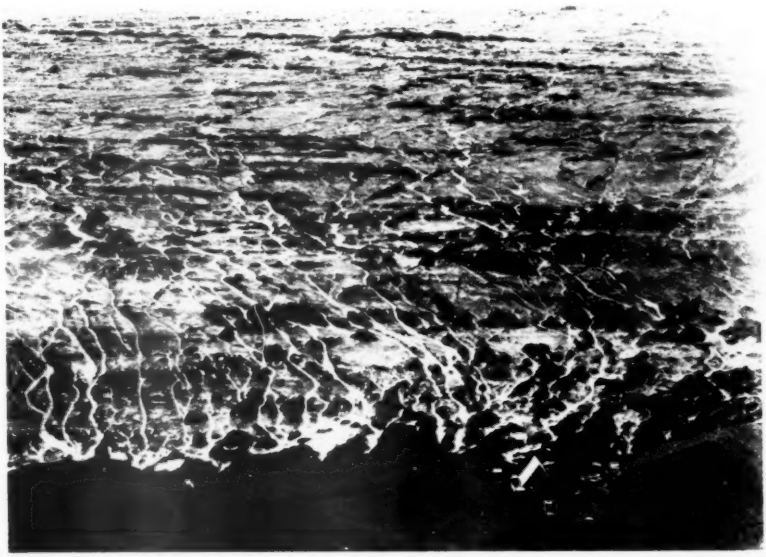
On July 11 the few small patches of remaining hard snow began to give way: in every direction there was nothing but deep wet slush; and in places great lakes of shallow water about a foot deep. We again found ourselves wading through slush, which was steadily becoming more fluid and increasing in depth. Soon the leading sledge got completely stuck, and the united efforts of all six of us failed to move it. The second sledge was left on a little island of ice, and after an hour's very hard exertion we managed to move all the boxes to a place about 100 yards away where there was a crust of ice sufficiently strong to carry the weight of the sledge again.

The rest of the gear was brought in gradually in four relays, and this was not completed until early the next morning. However the most lasting memory of the night's work will always be of the colours of the sunset, and our first sight of the lava desert to the north. Sunset and sunrise are here one long continuous blaze of colour lasting three or four hours each night, and as the sun moves round just below the horizon, all the colours move round from west to east too, and are strangely accentuated by the volcanic dust in the air. On this particular occasion there arose from the point of brightest light a fiery shimmer as though the whole desert to the north was one mass of fire. Out in the desert there were two black and sinister-looking peaks to which we gave the name of Vítisvegur (The Gates of Hell) because of the crimson glow behind. To the west of these the succession of razor-like ridges of Kverkhnúkaranar stood out inky black against the misty blue of the distant volcano of Askja. Farther east rose the pyramid-shaped cones of Upptippingar, and the pink summit of Snæfell. All this was reflected on the newly frozen surface of the thaw pools which appeared like so many vast mirrors in a sea of grey snow.

On reaching Brúarjökull, a lobe of the ice-cap stretching some 15 to 20 miles to the north between Kverkfjöll and Snæfell, the chief feature is the wonderful development of dirt cones all round its border, due to the large quantity of dust blown from the volcanic region to the north.

On July 14 we pitched our Base Camp on the marginal moraine of Brúarjökull, which is here about 3400 feet above sea-level. The surrounding district

Sledging over the dissected, dust-covered surface of the northern margin of Vatnajökull



Looking over Vatnajökull from above base camp (right foreground); ice-cap drained by thaw streams

Base camp at Kverkfjöll Eystri

Source of the Kreppa

was most desolate. To the north there was an impressive view of the Ódáðahraun; an extensive desert of black sand and scoriaceous lava. At the edge of the ice, within half a mile of our camp, there was a small lake, some three-quarters of a mile long, which we named Þorbergsvatn, after our guide of the south coast. Its eastern shore was formed of ice cliff 90 feet high; well-marked terraces indicating that within comparatively recent times it had been much larger and deeper than it is at present. The higher ground consisted of black dome-shaped hills and ridges bounded by loose screes; between these there were morainic dumps, having the appearance of the intermingled refuse heaps of a brickfield, cement works, and coal mine. The whole was dominated by the eastern scarp of Kverkfjöll, rising like a great wall 2000 feet to a flat ice-capped summit.

The geology of this region proved to be of great interest, and it was decided that the surveyors, Lewis and Beckett, should first of all make a large-scale map of Þorbergsvatn and its immediate surroundings for the geologists to work on, and later a smaller-scale map of the western border of Bruarjökull, which appeared to be very different from the existing map. Our previous plan of mapping Brúarjökull was based on the assumption that the Kverkfjöll region, obviously of far greater geological and topographical interest, had been accurately mapped. The Ódáðahraun is the greatest lava flow in Iceland. It is almost entirely devoid of life owing to the high porosity of the soil and the constantly shifting sand.

Twenty miles north of our Base Camp an oasis, Hvannalindir, was known to exist, and this had already been visited as many as eleven times, but in spite of this no scientific work had been done there, and very little was known about it; so while the geologists and surveyors were occupied near Kverkfjöll, Falk and I took a tent, and rations for ten days, and started off on July 14 to walk there to study the plant and bird life of the oasis, while the others continued the work round the Base Camp.

Owing to the initial mistake of trying to carry too much over country consisting of continual scree slopes, we succeeded in covering only about a mile before camping. One of the things which impressed us most while on the ice-cap was the remarkable clearness of the atmosphere. At first we were in the habit of ridiculously under-estimating distances, a mistake which was now reversed, and each small volcanic peak gave the impression of enormous height. Our first camp in the desert was pitched in a fog on a little flat shoulder of black cinders; and the next day, as it was raining and the fog continued, we took half loads to try and prospect a route through the mountains down to the desert. Leaving the camp standing, we tried to descend into a very impressive gorge about 300 feet deep, as this appeared to be a possible way out into the lowlands. A waterfall however prevented further progress, and we were forced to keep along the top till we finally found a snow bridge across the gorge and made a depot the other side before returning for another night at our first camp. The fog and the complete sameness of the country, combined with the fact that our compasses were quite useless, made it a great relief to find our camp once more after a long search.

The next morning we reached the depot in two and a half hours and went on through gradually flattening country towards Vítisvegur. The surface now

consisted of a great level pavement of lava pebbles set in loose black sand. Occasionally a few plants of "Melgras" (*Elymus arenarius*) showed up, and also a few Sea Pinks (*Armeria maritima*). In the afternoon we reached the edge of the Kreppuhraun, a wide stream of lava contorted into the most fantastic shapes. Late that night we suddenly came upon a little oasis. The water came bubbling up through the black sand in dozens of clear springs, and formed a little lake about three-quarters of a mile long bounded on the north side by a *hraun* or post-glacial basaltic lava flow, and on the south by the featureless desert of weathered lava we had been crossing all day. We pitched the tent on a bed of soft green moss and dwarf willows. The buzz of insects, the quacking of ducks, and the luxuriant vegetation all combined to make the contrast still greater between this oasis and the desolate region to the south.

On July 17 we spent the morning collecting. The number of species was small, but those present were interesting, and a definite zonation was noticeable. After dumping some food for the return journey we started at midday across another stretch of *hraun*. There is no outlet river to this oasis and the water flows under the lava here for nearly a mile and bubbles up again to make a fresh oasis on the far side. From here a river runs along the edge of the *hraun;* and being unable to cross it, we had to continue walking through the twisted masses of lava while only a few yards away across the water there was a smooth mossy bank the whole way. At the end of the *hraun* we came to another small lake on which were swimming a pair of Whooper swans and several ducks. Many attempts to shoot one of these with a revolver failed, so we went on, hoping they would be there on our return. We continued through more desert and finally came quite suddenly to Hvannalindir, much sooner than we had expected. This oasis was discovered by a farmer called Pjetur Pjetursson in about the year 1830. A greenish yellow streak of vegetation and bright threads of water lay in a long depression below the general level of the desert, at the foot of a very thick lava flow. In the middle of this plain there is an isolated and very regularly formed little cone called Lindakeilir, some 80 feet above the surrounding marshy flats. From the foot of this cone, and also from under the lava flow, many springs rise which form the stream Lindakvisl, which finds its way into the Kreppá, a tributary of the Jökulsá á fjöllum. For a mile or more the black volcanic sand along the river is hidden under a luxuriant covering of willow, grasses, and moss. The name Hvannalindir is derived from the *Archangelica officinalis* (Hvonna), which grows together with Willow Herb (*Epilobium latifolium*) on the banks of the river. The streams were full of algae, and Red-necked Phalaropes swam in and out among the broad leaves of the Angelica.

We pitched camp in a very pleasant situation between two streams near Lindakeilir and spent the next three days making a collection of all the forms of life in the oasis. One day we climbed a peak about 3 miles west of Hvannalindir from the top of which there was a view that made us realize that previous visitors to this region were not exaggerating in their attempts to do justice to such a scene. We saw also why Thoroddsen considered that these mountains were the strangest in Iceland. To the south the landscape was a picture of wildness and desolation. A confusion of numberless small peaks more or less the same height: some regular cones, others broad, some tooth-like, like

stumps and pillars, and others like rocky castles. Between them small sandy plains and hollows, and in each hollow there was lava which had flowed out through every gorge and defile northwards onto the plain. There were occasional red sedimentary hills, and here and there a group of projecting rocks which resembled the ruins of a town. Beyond, Kverkfjöll itself rose high above them all, with its glistening snowfields standing out in sharp contrast to the jet black of the foreground. Two columns of steam rose up from the solfatara district of Kverkfjöll Vestri. These solfataras were visited by J. P. Koch in 1912, but their existence had been recognized for a long time previous to that date. Only one eruption of Kverkfjöll in historic time is recorded, in 1717.

The presence of numerous solfataras and craters in this district which we had been led to expect by previous writers appears to be founded on impression rather than on actual fact. To the west the whole plain north of Dyngjujökull and several points between us and Kverkfjöll seemed to be steaming, but every one of these apparent solfataras that we reached proved to be a delusion and was probably due to eddies of dust raised by the wind. Another feature of this district was the ever-present smell of sulphuretted hydrogen. This smell is called *Brennisteinsfýlu* (*i.e.* Sulphur Stink) by the Icelanders, and occurs everywhere in the island where there has been recent volcanic activity.

On the evening of July 20, having made as complete a collection as possible of the plants, insects, and birds of the oasis, we started on the journey back to the Base Camp. Our loads were much lighter on the return and we made good progress. Early the next morning we reached the first oasis again, and before turning in we were fortunate enough to see a Whooper swan swimming on the lake, which we succeeded in killing after twelve shots with the revolver. The following day the Kreppuhraun was recrossed with the swan slung on a tent pole between us, as we intended to take it back to the Base Camp. On the eastern edge of the Kreppuhraun we reached the banks of the Kreppá. The cold yellow-grey waters of the river were deep and fast-flowing, with blocks of ice racing past in the fog, and sometimes crashing against each other. It was previously thought that the Kreppá probably had its source in Tómasarvatn, a small glacial lake on the margin of Brúarjökull, near Vítisvegur; but on reaching Tómasavatn we found that it no longer existed; and only a series of well-defined lake terraces showed where it had been. Near here the Kreppá is peculiar in that it flows for several hundred yards in an open channel between precipitous walls of dirty ice 80–100 feet high. The river is about 60 feet wide, and the water is shallow and dotted with small bergs stranded here and there in the centre of the stream. The water is very dirty and a large amount of solid matter is brought down in suspension.

We camped just south of this ice-gorge in an empty lake-bed near the twin peaks which we had called Vítisvegur, and a discussion ensued as to which side of the gates Hell actually lay. It was finally decided that the north, from which we had just come, had the better claim. The Kreppá has its chief source in Þorbergsvatn, farther south, while it is considerably swelled by the streams running through the deep gorges to the west, and the thaw streams flowing from the entire western margin of Bruarjökull.

Late on July 22 we reached the Base Camp once more and found that a great deal had been done during our absence. A number of hot springs having

a maximum temperature of 62° C. had been found at the bottom of Hveragil, the gorge we had tried to descend on our outward journey. Maps were on the way to completion, and a great pile of rock specimens testified to the activity of those of the party who had remained at the Base Camp. Fuller accounts of the work done at this time by the other members of the expedition will be found in the Appendices.

Our return across Vatnajökull was delayed by a storm, which confined us to our tents for another five days. Since our outward journey a considerable amount of thaw had taken place, and the surface of the ice had been much lowered and cut up by the continued rain and warm weather. The streams draining the ice had cut deep channels, leaving the dirt cones standing high between them. Sledging across such a surface was out of the question, and so we carried all our gear on our backs in relays for some 2 miles until we reached smoother ice. Perfect conditions for sledging followed, clear skies and a frozen surface enabling us to reach the southern edge of the ice, near our first camp, in only three days, when approximately the same distance had taken us fifteen days on the outward journey. We avoided the slush and thaw-pools of our outward journey by keeping close to a high snow-bank running south-west from Kverkfjöll. The fine weather made sledging thoroughly enjoyable. On the outward journey our heavy loads and the sticky nature of the surface had prevented us from ever doing more than about an hour's pulling at a stretch without a rest, and we found that we could not keep it up for more than five or six hours even when travelling by night. On the return however, with ideal sledging conditions we were able to do three or four hours at a stretch and carry on all day.

It had been our original intention to reach the edge of the ice-cap about 60 miles farther west, but we had to pick up the seismograph, and also our food supplies would not have carried us so far. When fully 4 miles from the southern edge of the ice we were astonished to meet our mountain guide, Skarphjeðinn, walking to meet us with his pony. We endeavoured, with ungraceful success, to control our skis and the sledge, whilst the latter towed us at an alarming speed downwards over the steep frozen slopes of snow. Our method of retardation was unorthodox, and often necessitated such extreme measures as being dragged along in various prostrate and uncomfortable attitudes. It was in this unusual manner that we finally reached our guide, who shook hands heartily, in spite of the fact that some of us were completely entangled in our skis and harnesses, and lay on the ground quite unable to get up. We learned that he had dreamed we were returning by the same route, in spite of our instructions for him to meet us nearly 60 miles farther west and ten days later. Furthermore he had felt compelled to come up the difficult mountain route in the hopes of finding us. Whilst we all remained mystified as to the genuineness of his dream, it was very convenient, as he was able to lead the way between the numerous crevasses near the ice-edge, where we were soon following the sledges in a more orderly fashion down the gentler inclines back to our first camp. He was able to go straight down and bring up the pack-ponies on the next day (August 1), thus saving a long delay. In this neighbourhood the extensive thaw of the last month had removed the *névé* covering of the ice, at this point some 40 feet thick as measured in crevasses on the outward journey.

Old lake basin south of Vitisvegur ("Gates of Hell")

Typical lava desert north of Vatnajökull

Vorbergsvatn

This completely altered the appearance of the ice-edge. The glacier (Heinabergsjökull), alongside which we pitched our first camp, had now become clearly differentiated from the main mass, and large and numerous crevasses which had previously been hidden were exposed on every side. The ice-edge was further dissected by the deeply incised meanders of thaw streams, and these, added to the absence of any snow covering, made the management of sledges very difficult.

Skarphjeðinn returned on the next day with pack ponies, and we wasted no time in descending to the grassy meadows in Staðardalur, where we intended to camp for five days at a place called Selhólar. This valley is about 5 miles long from the glacier to the sea, and offered an excellent field for an ecological survey. Our object was to study all the forms of life, both floral and faunal, inhabiting a given area and to discover the methods and order in which the colonization was taking place on the bare rock of this area so recently formed by volcanic eruption. At the present stage of the investigation it is impossible to give any detailed information on this point, but all the collections, including those made in the north, are now in the hands of specialists, and it is hoped to publish the results of their work in the near future.

On August 5 we started on our return journey across the outwash gravel plains and lagoons between the mountains and the sea beach. The interest of this was considerably increased by the greatly swollen state of the numerous rivers. These required great care and skilful guidance to negotiate in safety. Several times it was necessary for the ponies to swim across the deeper channels carrying us on their backs, and on these occasions some considerable time had to be spent in careful reconnaissance in order to choose places where the current ran least swiftly. We were naturally anxious during these crossings for the safety of our baggage, and although nothing was lost, all our equipment got very wet each time. Having returned to Hornafjörður we spent another five days continuing our ecological work in this district.

We had hoped to return to England by trawler again from one of the fishing stations on the east coast, but the fish had moved farther north and the trawlers had followed them; so we were forced to charter a small and very leaky motor-boat to take us the 200 miles along the coast to the Westman Islands (Vestmannaeyjar). This voyage started pleasantly on August 14 in brilliant sunshine and a calm sea; and the views of the mountains and the glaciers descending from Vatnajökull were very fine. The vibration of our engine was the only thing to mar this part of the voyage. But about midday the skipper of our craft pointed to some ominous-looking clouds that were gathering on the northern horizon, and we began to understand why he and the other three members of his crew had kissed their relations so affectionately on the quay at Höfn before we started. Towards evening the wind began to freshen, and at 4 a.m. the storm was at its height. The boat behaved valiantly considering the enormous seas; but sea-sickness, a thick fog, and the fact that the skipper had not only lost his chart but also his head did not add to our peace of mind, and it was a great relief and much to our surprise when the Westman Islands finally loomed up on our bows after twenty-eight hours.

From there we were picked up by *S.S. Goðafoss* on her way from Reykjavik, and we reached Hull on August 20. Our last view of Iceland from the deck

showed us Vatnajökull in the mood we knew best. Below, the foothills were in brilliant sunshine, but the ice-cap itself was obscured under the familiar covering of fog.

APPENDICES

I. NOTE ON NAMES

There appears to be considerable variation in the spelling of many Icelandic place-names. For this paper, those appearing in the maps of the Danish General Staff have been adhered to over the area they cover along the southern border of Vatnajökull, while those to the north of the ice-cap are from Trautz's map published in 1919,[1] and from Wadell's of 1920.[2]

Several new names have been added to the map of Iceland, and are to be found on the maps accompanying this paper. They are as follows:

Hveragil = Hot Spring Gorge.
Kambryggjuvegur = Cambridge Way.
Krókagil = Winding Gorge.
Kvislargil = Forking Gorge.
Rauðutindar = Many Red Peaks.
Skarphjeðinnsjökull = Skarphjeðinn's Glacier.
Svörtutindar = Many Black Peaks.
Vítisvegur = The Gates of Hell.
Þorbergsá = Thorbergur's River.
Þorbergsvatn = Thorbergur's Lake.

The above names have been agreed to by the Prime Minister of Iceland.

II. SURVEY. By J. A. Beckett and W. V. Lewis

The work of the surveyors consisted of the construction of two maps of the district surrounding the Base Camp at Kverkfjöll; one on a scale of 12 inches to a mile, and the other on a scale of 1 : 50,000.

The large-scale map included Þorbergsvatn and its immediate neighbourhood, and was completed first as it was required by the geologists for their work on the lake basin. A base about 600 feet in length was chosen on the small deltaic flats north-west of the lake and was measured with a 100-foot tape. The ground was contoured at 20-foot intervals, this work being greatly facilitated by the numerous raised beaches surrounding the lake, the best defined of which was exactly 100 feet above water-level.

The second map included all the country round the Base Camp over which the geologists had worked, and which was originally thought to have been completely surveyed by Max Trautz. The scale of 1 : 50,000 was recommended by the Danish Geodetic Institute, who intend at some future date to map the whole of the interior of Iceland on a scale of 1 : 250,000.

It was quite impossible to find any area on the land suitable for a base, and so one was chosen down on the ice sufficiently far removed from the land to give a good view of the numerous cones and ridges which were to be mapped. The base, approximately 1300 yards in length, was measured with a sledge meter constructed by Messrs. Kelvin, Bottomley and Baird. Successive runs over the

[1] M. Trautz, "Am Nordrand des Vatnajökull im Hochland von Island," *Petermanns Mitteilungen*, 65 (1919), 121–126, 223–229

[2] H. Wadell, "Some Observations from the Greatest Glacial Area in Iceland," *Geografiska Annaler*, 2 (1920), 300–323.

base with this instrument gave readings which agreed within the plottable error of 15 yards, and when standardized with the 100-foot tape over a typical section of the base-line, 600 feet in length, it was found that the reading had to be increased by 4·17 per cent.

Fog and rain storms so interrupted the work of the surveyors that after two and a half full days had been spent on the first map, only a similar period was available for the completion of the second one. For this reason the contouring of the cliffs of Kverkfjöll has had to be done from photographs, after numerous controlling points had been fixed in the field. In the foothills to the north-east of this cliff the relief was so rugged that the valley bottoms frequently could not be seen from the hill-tops, and in extreme cases could not even be reached by the surveyors encumbered with a plane-table. Therefore, to assist in the contouring of the area in the short time at our disposal, traverses were made across the more inaccessible valleys from one fixed point to another, barometer readings being taken at definite intervals. The barometer could be read accurately to 5 feet, which was within the accuracy obtained with the longer rays on the Indian clinometer.

The surveyors were unable to take a theodolite owing to the limited weight of the instruments which we were able to carry across the ice-cap. We were also unable to resect our position, as only one peak whose co-ordinates have been fixed by the Danish Geodetic Institute was visible from the area in which we worked, and thus we had to rely on Trautz's observations for our latitude, longitude, and azimuth. His trigonometrical points could not be sighted, so the hills of Vatnahryggur, which were the most clearly defined landmarks present on both maps, were used as the points of contact between his map and ours, and azimuth was determined from several rays drawn to distant points marked on his map. Trautz's map was constructed from a hurried photogrammetric survey, starting from a base fixed by astronomical observations. He gives a probable error of 18 metres for one of his latitude observations and 300 metres for the other, and these inaccuracies must have been further increased as his survey extended the 10 miles from the south end of his base to Vatnahryggur. Thus the latitude and longitude lines marked on our map, being subject to these errors, are only approximate.

It was impossible to obtain our actual height above sea-level from his map without using rays over 10 miles in length. Such excessively long rays with the Indian clinometer would give most inaccurate results. On the other hand, our barometer observations at the Base Camp extended over a fortnight and could be compared with the readings taken over a similar period at the meteorological stations at Reykjavik, Akureyri, Seydisfjörður, and Hólar. It was therefore decided to use these records as the basis for calculating a datum for our contour heights.

All the surveying instruments were kindly lent by Professor Debenham.

III. GEOLOGY. By F. W. Anderson

The geological work of the expedition consisted chiefly of an intensive survey of the eastern side of Kverkfjöll and the lava flows lying to the north and east of it; a comparatively small area, but one of considerable interest. In addition, the lava flows and intrusions which form the mountains of the south coast were studied at Kálfafellsstaður and Hólar.

Kverkfjöll, projecting from the northern edge of the Vatnajökull between the lobes of Brúarjökull and Dyngjujökull, presents a massive scarp to the east some 5000 feet high, carved out of faulted black and yellow tuffs. Between this scarp

and the ice-edge are a number of lava flows which have apparently been extruded under the ice at a time of much greater extension of the ice-cap. Some of these lava flows are interbedded with lake silts showing that their eruption must have caused extensive melting of the ice. The lava flows are obviously the result of more than one fissure eruption and of comparatively recent date, for though erosion is proceeding very rapidly it is still possible to trace the extent and direction of the individual flows without much difficulty.

Perhaps the most valuable information yielded by this area is that concerning the erosion and deposition of these light vesicular lavas. Accordingly, a detailed study was made of a small river, Þorbergsá, and the very fine delta which it is building in the marginal lake, Þorbergsvatn. As an example of the rapidity of the changes taking place even daily in this landscape it was noticed that the main distributory of this river worked across the whole width of its delta in four days.

At the southern end of the lake a stream is depositing a tufa screen and is rapidly forming amygdaloidal lavas of the vesicular flows in the neighbourhood.

On the south coast the country rock is built up of a large number of basalt flows, massive below, vesicular above, and separated by a thin red lateritic deposit. These are interrupted in many places by considerable intrusions and their numerous apophyses. One such, forming part of the Ketillaugarfjall, near lake Þveit, Hornafjörður, was studied in some detail and proved to be a composite intrusion of Gabbros and Granophyres with many Dolerite dykes piercing the surrounding and overlying basalts.

IV. GEOMORPHOLOGY. By W. L. S. Fleming

(*a*) *Kverkfjöll.*—The topography of the district which we explored was both interesting and unusual. In addition to normal fluvial action, wind, ice, and subsurface waters have all played a prominent part in the sculpture of the land. But perhaps the most remarkable feature of the district is the rapidity with which the land-form appears to be undergoing change. The severity of the climate, the paucity of vegetation, and the facility with which the volcanic country rock disintegrates are in large measure responsible for an unusual rate of erosion.

On the west the area is bounded by the 2000-foot ice-capped cliff of Kverkfjöll Eystri. Towards the north this scarp, which seems to have been initiated along a fault-line, swings westward. Near the scarp tuff ridges of serrated profile extend down from Kverkfjöll, but farther away from it they give place to discontinuous lava hills of characteristic dome shape. Although glacial action has been chiefly responsible for the form and position of these hills, faulting has also played a part. The hills are bounded by screes with a slope of as much as 34°, and they are remarkable inasmuch as the material of which they are composed shows very little sorting and the gradient scarcely changes from top to bottom of the slope. This may be explained by the fact that the screes consist principally of finely comminuted black lava sand in which larger vesicular fragments are held by friction at the angle of rest of the finer material.

Nearer their heads the valleys are of typical glaciated U-shaped profile. The position of morainic deposits in these valleys, a mile or more from the foot of the scarp, indicated the former extent of glaciers descending Kverkfjöll. Only one of these glaciers, Skarphjeðinnsjökull, persists at the present day, and this flows no more than a few hundred yards from the foot of the scarp, though its terminal moraine reaches the western shore of Þorbergsvatn.

At the present day Skarphjeðinnsjökull descends from the summit of Kverkfjöll

Eystri as a constricted, steeply inclined glacier. Near its terminus however, where the underlying terrain changes abruptly to a more gradual gradient, and where the glacier emerges to a wider part of the valley, the ice splays out fan-wise, and this spreading movement has given rise to large radiating crevasses. The glacier is building both lateral and end moraines in which many tuff boulders 20 feet or more in diameter are incorporated.

Below their U-shaped glaciated portions the more northerly of the valley heads in Kverkfjöll Eystri swing northwards, and the rivers draining them have cut deep gorges leading to a large pan-shaped depression extending northwards as far as Vítisvegur. Over a large part of this area the surface is porous and the drainage takes place by underground seepage. Most of the small streams which find their source in the melt-waters from snow banks do not extend many hundred yards before sinking underground, leaving their load of fine silt on the surface. The seepage waters are seen to emerge as springs above impervious rock outcrops.

The pan-shaped depression south of Vítisvegur consists of a type of desert flat of which there are many representatives farther north. The most characteristic feature of these fluvial and lacustrine flats is the concentration at their surface of a mosaic of pebbles due to the removal of the finer material by wind. West of Hvannalindir the pebbles have been polished and pitted by aeolian action and have a typically dreikanter shape.

In addition to the desert flats, the topography between Vítisvegur and Hvannalindir consists of ridges and *hrauns*, or post-glacial basaltic lava flows possessing all the characters of size and shape of a highly fluid extrusion. Extremely rugged and broken in surface, these *hrauns* follow the directions of the pre-existing valleys and depressions, broadening out where these are widest and being constricted where they were narrow. Oases and springs are found at the edges of the *hrauns* where the underground flow beneath the porous desert flats is obstructed by solid lava rock.

Þorbergsvatn, approximately a mile in length, is bounded and dammed by Brúarjökull on the east. A series of raised beaches and one well-defined overflow channel testify to the recent oscillations of the lake-level. The highest shoreline, approximately 240 feet above the present water-surface, is the oldest, and since its formation the lake has progressively fallen to its present level. The outflow of Þorbergsvatn is infra-glacial and constitutes one of the main sources of the Kreppá which emerges from beneath the ice some 4 miles farther north to follow the margin of Brúarjökull for the next 3 miles of its course.

East of Vítisvegur, another lake, Tómasarvatn, whose eastern shore is formed by the edge of Brúarjökull, was found by Trautz. To-day this lake no longer exists, but there are well-defined recent lacustrine shore-lines corresponding in position and outline to Trautz's description and photographs of Tómasarvatn.

(*b*) *South coast.*—Lewis and I co-operated in making a geomorphic study of the greater part of the area between Breiðamerkurjökull and Vestur Horn. The main features are clearly indicated on the Danish General Staff maps, which cover the whole of this area.

The district is divided into three clearly defined natural regions. To the south there is an offshore beach at present under process of construction. Behind this lies a lagoon which is being rapidly infilled by fluvio-glacial deposits so that its northern part constitutes an outwash plain. A marine cliff separates this latter region from the glaciated mountains which extend to the southern edge of Vatnajökull. A study was made of the glaciation of the mountain region and the control exercised by the structure of the country rocks. Most of the valleys in the mountain region are occupied by valley glaciers descending from the ice-cap

practically down to sea-level, and in some of them evidence was obtained of recent glacial recession.

A number of different types of lakes, including several rock basins, were found in the area south of the ice-cap, and special attention was paid to them.

V. GLACIOLOGY. By W. L. S. Fleming

For the greater part of the time that we were on Vatnajökull the temperature was above freezing-point. The effects which the thaw produced on what, in winter time, would be a smooth ice-field, increased from the summit of Vatnajökull towards its borders. Near the centre of the ice-cap there was an even *névé* surface covered with a very small amount of wind-blown dust. The aeolian debris increased in quantity and grain size towards the north (*i.e.* in the direction of its origin), and about 8 miles from Kverkfjöll it was sufficient in amount to give rise to dust wells. A mile or so farther south Bruarjökull was covered with thaw pools and melt-water streams, and in one place Roberts observed the whole surface of semi-liquid slush moving in one mass into a transverse crevasse. This slush was about a foot thick and was moving over a surface of hard ice. Still nearer the ice margin the winter's precipitation had all been melted and superglacial streams had begun to dissect the exposed ice into a grike-like pattern. Aeolian and englacial debris had been deposited as silts along drainage channels following both the crevasses and lines of greatest slope. To the concentration of these silts the remarkable development of dirt cones and ridges which characterized the margins of Bruarjökull is due. A mile from the ice-edge small isolated dirt cones and ridges were found, but nearer it these were very numerous and up to 20 feet in height. In some cases at the apex of a cone the stratification of the silt responsible for the insulation of its core was visible.

The intensity of the summer thaw may be gauged by the fact that when we reached Kverkfjöll early in July, within a radius of a mile from the edges of Bruarjökull, the winter's fall of snow had already been melted, and during the fortnight when we were at Kverkfjöll, the edge of the ice was very considerably lowered, and its margin greatly steepened.

The drainage of Tómasarvatn, the progressive lowering of Þorbergsvatn, and the shrinkage of Skarphjeðinnsjökull all indicate glacial recession in recent times. Owing to the fact that the ice has been deflected by the south-eastern edge of Kverkfjöll from the triangular-shaped land area which we explored (see map), this recession has not been accompanied by any eastward shrinkage of the western edge of Brúarjökull, but has simply resulted in a lowering of its level.

In places Brúarjökull has built lateral and end moraines, but these are insignificant in their proportions. By far the greatest part of the englacial debris from this ice-lobe is finely comminuted lava, such as that which constitutes the exterior of the dirt cones, and almost all of this is carried off by melt-water streams.

The rate of northward movement of Bruarjökull is small, but transverse crevasses, 1 or 2 inches wide and 50 yards apart, were found 17 miles south of Kverkfjöll, indicating that the ice movement, though slow, extends from the centre of Vatnajökull. Opposite Kverkfjöll itself, these transverse crevasses are somewhat larger and closer together, but the deepest crevasses in this peripheral part of Brúarjökull are marginal, occurring where the ice-edge is free to move outwards. Where, on the other hand, the edge of the ice abuts against lava hills or ridges, the movement being retarded, the crevassing is not developed on such a large scale. In these latter localities the shear planes and dirt bands in the ice curve upwards towards the rock buttresses.

The cross-section (see folding map) shows that the gradient of the south side

of Vatnajökull is much steeper than that of Brúarjökull. Whereas, in the case of the latter, movement is slow, and wastage takes place almost entirely by ablation, the southern edge of the ice-cap is moving faster. Furthermore, on the south an outlet is afforded to the ice by large glaciers which flow down most of the major valleys and descend nearly to sea-level. On our return to our first camp site on the south of Vatnajökull we found that the thick covering of *névé* had been melted to expose a crevassed ice surface. The contours of this southern margin showed a great change from what they had been five weeks before, and in place of a series of smooth step-like banks, we found a surface more akin to downland rising and falling in steep swells and swales, 300 yards or more in breadth.

VI. BOTANY. By P. Falk

A survey was made from an ecological point of view of the flora in Kverkfjöll and the desert as far north as the oasis Hvannalindir, and also on the south coast. The desert provided very suitable material for this owing to the simple way in which such factors as warmth, water supply, and movement of the soil could be seen to act at the hot springs, oases, and scree slopes. In conjunction with the zoologist the stages of colonization of the desert were examined and the probable succession determined. A collection of phanerogams and bryophytes, together with the most important algae and fungi, was made for subsequent examination and identification.

In the Ódáðahraun the most striking feature of the vegetation is its sparseness. This is due to the continual motion of the surface soil and to its low capacity for retaining water. Consequently, apart from such plants as are able in some measure to withstand these conditions, there is no vegetation except on the smooth mountain tops where the surface is more stable, and on the banks of the rivers where the water supply is particularly abundant. Thus it is possible to walk in the valleys for days without seeing any healthy plants other than Sea Lyme Grass (*Elymus arenarius*) and Sea Pink (*Armeria maritima*); but if one ascends the scree slopes, at the top the weathered lava may be covered with Dwarf Willow, Fescue Grass, Mountain Sorrel, and Saxifrages of several species, in addition to the beautiful *Veronica fruticans* and many other alpines.

The oases, which originate between the meanderings of rivers and round the margins of lakes where the soil has an abundant supply of water, have a characteristic flora of Willows (*Salix herbacea*, *S. phylicifolia*, *S. lanata*) and Grasses (*Calamagrostis stricta*, *Aira alpina*, *Festuca rubra*), with Eyebright (*Euphrasia latifolia*) and *Polygonum viviparum* forming a type of heath, giving way to swamps with Cotton Grass (*Eriophorum scheuzeri*) and species of rush and sedge in the wetter parts.

Near Kverkfjöll an interesting feature was the zonation of the vegetation round the hot springs. No species of flowering plants were found there that did not occur in other parts of the desert, but their growth was more luxuriant and their zonation, together with the consequent zonation of animal life, presents an interesting ecological problem. An alga which grew in the hottest water (62° C.) was collected and is being identified.

On the south coast the most detailed work was done in Staðardalur. As a result of its bottle neck, this valley was particularly sheltered, and various stages in forest formation could be traced. The forest, which is never more than 3 feet high, is formed at the bottom of the scree slopes but does not extend into the centre of the valley due to the extensive river-bed, which is continually changing its course and thereby preventing the permanent establishment of any vegetation. Owing to the movement of the scree slopes, the life of any part of the forest is

extremely limited, and no birch tree of more than thirty years of age was ever found. Additional evidence of the destruction of forest by movement of soil down the scree slopes is provided by willow and birch branches almost entirely submerged beneath heaps of fallen stone and lava. The forest in Staðardalur contained only one species of Birch (*Betula odorata*), but at Höffell there was mixed birch (*Betula nana*, *B. odorata*, and their hybrid).

In the moister parts of the valley Meadow Grass (*Poa pratensis*) took the place of Fescue Grass which extended downwards from the edge of the bare screes, and Grass of Parnassus (*Parnassia palustris*) was exceedingly common. With the increase in moisture near springs and streams several species of Sedge (notably *C. rigida*) replaced the *Poa*, but rushes were infrequent. In some moist places Horsetails (*Equisetum arvense* and *E. palustre*) are more common than either grasses or sedge. This was sometimes the case even on ground which was scythed, and in such places the frost hummocks were always conspicuous.

In the tun round the houses potatoes are grown, and there are often trees of mountain ash (*Sorbus aucuparia*) and Siberian Larch (*Larix sibirica*), with occasional willows. The only cereals that are cultivated are rye and a little Indian corn. In addition rhubarb is grown and certain weeds such as Knot Grass (*Polygonum aviculare*) are found within the tun, but only rarely outside. The plants commonly grown for show are Willow Herb and Aconite.

Altitudinal zonation is obscured by movement of the soil on the scree slopes, although above the birch forest there is a zone from 400 to 2500 feet where the saxifrages and Mountain Sorrel are very frequent. Above this, up to the level of the glaciers, lichens, which are otherwise uncommon, and mosses are dominant. On the bare shingle in the valley bottom stonecrops (*Sedum acre* and *S. villosum*) and the Iceland Poppy (*Papaver radicatum*) occur irregularly.

Even on the south coast the vegetation generally is sparse, due to the factors already mentioned, and also to the scanty snow covering in winter. The alkalinity of the soil, which was never more acid than *p*H 6·4, may also contribute to the barrenness.

VII. ZOOLOGY. By F. W. Anderson

The zoological investigations of the expedition were in the form of an ecological study. The zoologist worked throughout in consultation with the expedition botanist who defined the ecological types from which the animals were collected. Attention was confined chiefly to one aspect only of Icelandic zoology, the colonization of the Ódáðahraun, a lava desert to the north of Vatnajökull. To this end, extensive collections were also made from the coastal region to the south of the ice-cap, so as to form a basis of comparison with the desert fauna. A programme of intensive collecting was carried out in two localities on the south coast from the mountainous margin of the ice-cap to the coastal lagoon—in Staðardalur, from the Base Camp at Selhólar, near Kálfafellsstaður—at lake Þveit and in Laxardalur, from the Base Camp at Hólar. The desert was studied from the Base Camp at the foot of Kverkfjöll Eystri to the oasis of Hvannalindir, 20 miles north of Vatnajökull.

In the lava desert the factors retarding colonization are primarily shifting sand and scree which tend to smother any plant life which may have obtained a hold, and secondly a lack of water due to the high porosity of the rock. Where vegetation has obtained a hold, as in the oasis of Hvannalindir and in the neighbourhood of the hot springs of Hveragil, there is abundant animal life though the species are few.

The most widely spread colonizers belong, as might be expected, to the Insecta. Moths are to be found feeding on isolated plants of Thyme (*Timus*

Hveragil (Hot Spring Gorge)

Post-glacial lava flow near Hvannalindir

Luxuriant vegetation at Hvannalindir

serpiphyllum). Yellow dung-flies breed in the decaying green slime of the hot springs, round which mosquitos are also fairly common. Of the ground fauna, harvestmen are the pioneers, and isolated pairs are to be found at considerable distances from vegetation or any other form of life. In the neighbourhood of the hot springs spiders are abundant, with an occasional beetle.

Contrasting markedly with the scarcity of life in the desert, the fauna of the oases is rich in individuals and in species.

The study of the two valleys on the south coast, Laxardalur and Staðardalur, showed a similar colonization of the bare screes, though with a considerable compression of the ecological zones. There are at least ten ecological types distinguishable here, each with its own abundant fauna, with the exception of the streams in which the population is surprisingly sparse, bearing in mind the abundance of trout to be found in them. The shallow impersistent pools however usually contain Ostracoda; and midge larvae (Chironomidae) are to be found amongst the moss fringing small streams.

It was rather surprising to find that the earthworm is comparatively rare in the soil and moss and only occurs in special, usually wet, situations. In Staðardalur, for example, it was only found in wet pastures (*Equisetum* and *Carex*) under pony dung.

Mites are usually of wide distribution and are common wherever they occur. They were found generally by turning over flat stones. One species, superficially resembling the so-called Red Spider, is to be found in the open. Its red spherical eggs, ornamented with scattered bristles, are laid in large batches under stones. Ichneumons were common in most districts.

The ornithological work of the expedition was carried out by B. B. Roberts, and consisted of the collection and interpretation of bird stomachs with a view to discovering their feeding habits. He also carried out a general ecological classification of the birds in different habitats, and made a number of transects to give an idea of the relative numbers in different areas.

This report is necessarily brief and further details are to be published later, when all the specimens collected have been identified.

VIII. METEOROLOGY. By J. A. Beckett

Meteorological observations were made daily on the two crossings of Vatnajökull, and also during the fifteen days' stay at Kverkfjöll. Few previous observations have been recorded in this area, but a comparison of the scanty results shows a marked variability not only over short periods of two or three days, but over much longer periods as well.

The first point to be considered is the effect of this ice-cap upon winds and precipitation both on Vatnajökull itself and in its immediate neighbourhood. Anticyclonic conditions do appear to form over the central portions of the ice-cap, but these are very easily broken up by frequent cyclonic disturbances. However during periods of high pressure over Iceland as a whole winds certainly tend to radiate outwards from the central ice, but this condition is not very marked, even in midsummer. On the southern edge of the ice, where the mountains fall steeply to the sea, cold winds blow from the ice down the mountain sides with great frequency. This condition does not exist in the north owing to the gradual slope of the Ódáðahraun. The decrease in snowfall from south to north is one of the most striking features of Vatnajökull. In the south orographic precipitation is high owing to the frequency of south-west winds which are rapidly cooled on reaching the ice, and another factor explaining this is that the general height in the south considerably exceeds that in the north.

The northern slopes of the ice receive considerable quantities of moisture in the summer through convection. The lava desert heats rapidly under the influence of the sun and huge cumulo-nimbus clouds are formed with great rapidity. Their effect however is naturally only felt on the margins of the ice-sheet.

The winds from the north were usually of comparatively low humidity, and it is those from the south which cause the densest and most persistent fogs. The two periods of finest weather, each lasting for four days, followed upon periods of the worst storms, an interesting fact recorded by Wigner and Muir also during their journey in 1904.

Upon our arrival on the ice-cap on June 25 we found much fresh snow and 2° of frost. From June 30 until July 6 the thermometer only once touched freezing-point, although during the greater part of this period stormy weather prevailed. Rain and sleet fell for over one hundred hours without a break from July 1–5; the wind reached an estimated velocity of over 60 m.p.h. and went completely round the compass during this period. The snow surface was reduced by at least 20 inches during this storm, and we were able to record a minimum rainfall of 4·16 inches in nine hours, which is little less than the total one might expect for the whole of July.

When we reached the higher regions of Vatnajökull on July 6 a very heavy snowstorm was experienced. This snowfall was confined almost entirely to the southern slopes of the ice-cap, for shortly after starting the gradual descent to the north little fresh snow was evident. A well-marked anticyclone at Hólar in Hornafjörður corresponded with a fine period on the ice between July 8 and 13, when the barometer rose from 29·37 to 30·09 at sea-level. The air temperature rose to 50° F. at 10 a.m. on July 11, and at midnight on the same day it dropped to 29° F.

The mean temperature during the crossing of the ice-cap worked out from at least three observations per day was 37° F. The corresponding figure for Hólar was 53·04°.

During our stay at the Kverkfjöll Base Camp (3400 feet above sea-level) the temperature remained almost constantly between 35° F. and 40° F., an interesting figure in view of Thoroddsen's opinion that it seldom rises above 28° F. The wind blew with great regularity from the north, and fog was frequent, no doubt owing to the comparatively warm air from the Ódáðahraun meeting the glacier. Convection showers were frequent after a morning of sunshine. The period July 22–28 was marked by continuous fog, rain, and, during the nights, snow.

DISCUSSION

Before the paper the PRESIDENT (Admiral Sir WILLIAM GOODENOUGH) said: Small as Iceland is—rather under 40,000 square miles in area—it is a country of very great interest historically and politically, though that is not the business which we have before us this evening. Geographically, it is of immense interest. Within easy reach of our own country, it affords a variation of geographical conditions which is remarkable. Although far to the north, it has a comparatively mild winter. The harbours, especially those on the southern and western coasts, are free from ice. There is good vegetation. There are tremendous gales of wind nearly all the year round. In the middle of the island there are great ice-fields and snow-fields that afford opportunities for investigation by those who are interested in that particular form of glaciation. It is of those ice-fields that we are to hear to-night from Mr. Brian Roberts, who was the leader of an expedition the members of which came nearly all from Cambridge. We were very glad in this

Society to be able to assist them in some way, and to afford them an opportunity of trying an instrument which, though no great results were obtained from it on this particular expedition, will in future be of great value.

The expedition consisted of six in all—four non-graduates and two others, not very old, but still of slightly greater age. Mr. Brian Roberts was at school at Uppingham, and tells me he is still an undergraduate, so it is not to be expected that I have any very long personal history to tell you of him. Mr. Roberts.

Mr. Roberts then read the paper printed above, and a discussion followed.

The PRESIDENT: Mr. Lewis went with the expedition as seismologist and surveyor. I will ask him to say a few words.

Mr. W. V. LEWIS: The work of the surveyors was confined to the district surrounding the Base Camp at Kverkfjöll, and there Mr. Beckett and I did what we could in the occasional brighter intervals between Icelandic fog and depressions. We were not long in discovering that, at least in this part of Iceland, the climate was not suited to the surveyor. Out of the fourteen days we only had five whole working days, and in that time we had to produce two maps: the first one was a large-scale map of that beautiful little lake, Þorbergsvatn, near our Base Camp. The reason for producing this map, an extra to what we originally intended doing, was that the lake basin was found to be seething with problems geological and topographical. You might have noticed on the screen very interesting little terraces at different levels above the lake, showing that once the glacier had dammed back the waters at a higher level. Corresponding with those levels we could often trace the old outlet from the lake together with little river deltas now left high and dry and so inviting examination. Accordingly the geologists suggested our drawing a map to which they could add this interesting series of beach terraces and deltas. When that was completed we had to continue with a 1-inch-to-the-mile map of the district round our base, country which was almost entirely unmapped. This involved the mapping of the innumerable dissected lava domes referred to by Mr. Roberts. He said that numbering them from 1 to 28 made things very easy, but Mr. Beckett and I would consider that a gross overstatement of the truth. Standing on top of dome 13 and trying to decide which was 22, 24, or 27 was not as simple a matter as it was for the geologists to christen them! Eventually, I will not say we finished the map, but we went as far as we could in the short time at our disposal.

From the geomorphic point of view the ground we covered in Iceland was of extreme interest. There, with the temperature oscillating about the freezing-point and with the whole ground almost bare of vegetation, the forces of erosion and disintegration are found in their most severe form; changes which would have taken centuries to come about in England would there be accomplished in a season, or sometimes even after one storm. Further, the complete absence of vegetation lays bare every little detail of topography to even the most casual observer. The slides gave you a very good impression of the south coastal region, country brimful of interest to the student of topography. Here many of the problems which we met with were of far more than local importance, especially those associated with recent changes of sea-level.

The whole coastal region seems to be a marine-cut platform of enormous extent, bounded on the landward side by cliffs up to 3000 feet in height, and extending down to the present sea beach which is 4, 5, or 6 miles from the foot of the old cliffs. Over this flat stretch a series of glacial streams flow out in close succession, depositing vast quantities of gravel and black sand on their way to the sea. The latter has thrown up these materials into a great barrier beach which is pierced at intervals by the larger rivers and which extends along the whole of

the south coast of Iceland. Grasses have colonized the larger patches of sand and the Icelandic farmers have utilized every available plot to graze their cattle, sheep, and ponies. Many lesser marine-cut platforms, spits, and barrier beaches, now several miles inland and in a remarkable state of preservation, testify to recent changes of sea-level and give rise to a series of problems of great interest, and which may well lead to instructive correlation with similar movements of sea-level elsewhere.

On our return to the south coast, in addition to being very impressed with the details of topography, we were exceedingly thrilled with the food. Thence-forward we certainly lived on the fat of the land, and even the fat of Iceland is far better than a sledging ration of pemmican. Also we were greatly helped in our movements by having the ponies; you probably realized from the film how we enjoyed riding them. They are delightful little animals with just the right mixture of spirit and patience, this last quality being frequently tested when, encumbered with our stiff oilskins, we were making rather feeble attempts to mount them. It is really quite difficult to fall off an Iceland pony, and even if one does there is not far to fall. So in the coastal region we were well favoured, both from the point of view of our work and enjoyment, and in this we were greatly assisted by the extreme kindness of the Icelanders. It was a joy to experience their spontaneous hospitality. The traveller along the coast calls at the nearest farm at nightfall and is there given an evening meal, a bed and breakfast, and then starts out again on his journey. Though we came in for more elaborate entertainment than ordinary travellers, we really got the spirit of the thing and became greatly attached to the Icelanders, to whom we owe a debt of gratitude.

The PRESIDENT: And now I will call on Professor Debenham, whom I might term the sponsor of many expeditions of a similar kind.

Professor F. DEBENHAM: We have listened to a very excellent account of yet another expedition of what I should like to call the undergraduate type. Although there are many things one would like to remark upon in connection with the story Mr. Roberts has told us, I should prefer, with your permission, to make more general reference to a type of expedition of which this was one.

Since the war there have been more than twenty expeditions very much of this style: that is to say, a group of young university men, quite often led by an undergraduate, and a junior one at that, have set off and done work of this kind. This cult of the Arctic, if one may so term it, was, I think, founded by that extremely youthful veteran, Mr. George Binney, of Oxford, and Mr. J. M. Wordie, of Cambridge; and other universities have taken part in these now quite fashionable undergraduate expeditions. The work that they have done has had to be done in a short tine. They are summer expeditions, and sometimes consist of two men—there was a successful expedition to Bear Island this year of only two—sometimes they are as large as the Spitsbergen Expedition. But they are all alike in being amateur in what I call the best sense of the term. Again, they have always been very friendly with the natives, because these young men have had to go to lands not belonging to their own country, and have got on very well with the holders of those lands, as we have seen to-night. I am quite sure that Great Britain has made friends with the Danes, the Norwegians, and others who own land in the north, *via* these youthful amateur expeditions. It is sufficient indication of their singleness of purpose and purity of motive that when they have returned they have usually been thanked for the work they have done by the real owners of the land. Great Britain has many places in the sun but unfortunately no place in the snow, unless you go as far as Arctic Canada, which is rather distant for a vacation expedition, or to the still more distant Antarctic.

To sum up the matter, these expeditions are well worth while. This Society has been very prominent, in fact foremost, in supporting, either by such funds as it can command or by advice and encouragement, these university expeditions, and I am sure from what you have heard to-night and the way in which the lecture was delivered, that you will heartily endorse the action which your Council has taken. Occasionally these summer expeditions lead to something more extended, of more importance and of longer duration; and the fact that this is so is one well known to you in the greatest of these undergraduate explorers, whose loss we deplored a month or so ago. Gino Watkins led an expedition when he was eighteen, a little more youthful than Mr. Roberts, and went on to greater things. I would like therefore to express my firm opinion that this is only one of many expeditions led by amateurs who not only have great fun but who do great things at the same time.

When you read the lecture and its appendices in the *Journal* you will see there was a great deal of serious scientific work; as much as could well be squeezed into six weeks, together with splashing through rivers, psychic dreams, and so on. I am sure you will have enjoyed what Mr. Roberts has told so well, and I am very glad to pay my tribute to him for the excellent way in which he has given his lecture.

The PRESIDENT: Dr. Longstaff is President of what is now known as the Arctic Club. I wanted to call it the Arctic Club of Oxford and Cambridge, but he tells me I am not to, so I won't.

Dr. T. G. LONGSTAFF: There is a great deal that we Fellows of the Society can learn from an evening like this. I endorse every word that Professor Debenham has said, and would like to go a little farther. Professor Debenham, coming from Cambridge, was in the position of a godfather. I came from another place, and should be considered more as a stepfather.

Nowadays it is almost possible to go anywhere in the world, and do anything, if you have unlimited money. You can buy a local army to take you through the hostile Indians of the Amazon. You can bribe your way through countries in which you are not wanted. If you are congenitally or physically incapable of learning any reasonable language, you can hire interpreters to do the talking for you. Nowadays there is practically nothing in the way of travel that you cannot do if you have unlimited money. But it is not necessary to have unlimited money. There is still another way, curiously enough, of travelling, and that is to take the trouble to prepare yourself for the particular job you want to do. If you want to go through the Southern deserts of Arabia, you must be an Arabic scholar, like Bertram Thomas or St. John Philby. If you want to explore in the Arctic without spending a great deal of money you can learn the technique of Eskimo hunting, as Gino Watkins and his companions did. It is a case of mental equipment against money bags: of people who will take the trouble to read up, to learn beforehand, to acquire the necessary knowledge of the particular job they have got to do. If they will do that, they will accomplish good work for very little money indeed. We have had an example of that to-night.

I have had the pleasure of reading in full the paper of which Mr. Roberts has not read the whole to us this evening, and also the scientific appendices. Extremely good work was done by the members of his expedition: physicists, geologists, botanists, zoologists, and surveyors were sufficiently mentally equipped to go into that part of Iceland which is really almost a scientific laboratory, and profit by it. Between the Ice Cap and those northern volcanic deserts there are a whole series of laboratories. When you read in the *Journal* the scientific reports by these men you will see what extremely good use they made of their time; what really valuable work they have done; and, especially, when you read those reports

remember they are only the preliminary statements of work done. We can be certain that fuller reports will appear in other appropriate journals.

I was in great fear that Mr. Roberts would defeat the Oxford record of £57 9*s*. per head for a trip of this sort, but fortunately we were just saved; they were unable to come out exactly where they meant to, and had to hire, unexpectedly, a motor boat. They could not foresee the necessity of having to hire that motor boat to take them 200 dangerous miles to the Westmann Islands; they could not foresee that the boat that should have picked them up would not pick them up, and so they had the additional expense of hiring that motor boat, which was very costly. Even so, the expedition has only cost under £80 per head for six men for something over two months. I think that the Society will agree with the words of Professor Debenham and will very much approve of the action of the Council in supporting such expeditions.

I am an extremely impatient person, I know, but I never have any patience at all when people tell me that the Alps are played out. I always reply, "You mean you are played out." And when others tell me there is no more exploring to be done, I say, "There is an unlimited quantity"; but nowadays it is not any good people going on exploring expeditions if they are not going to fit themselves beforehand, as these men who went with Brian Roberts did, to be able to profit by what they see. There are any amount of travellers who go through a country and see nothing and, not being able to speak to a native, hear nothing. But the field is still quite unlimited. There is still plenty of room for travellers who will take the trouble to equip themselves with the necessary knowledge, and who are not afraid of roughing it a bit and do not expect to do themselves too well; in fact, who think nothing of seven men sharing the skipper's cabin in a fishing boat.

I am quite sure I shall echo the feelings of this audience in congratulating Mr. Roberts and his companions on a very sound piece of work, and, mind you, there was plenty of risk there. If things had gone wrong on that ten days' trek north from the Ice Cap into that desert country, if it had been too much for them, they would not be here now. They are here now because they were capable.

Mr. BRIAN ROBERTS: I just want to thank the other members of the expedition for the very magnificent way in which they supported me the whole time we were in Iceland, before we went to the Ice Cap and after we returned. After all, it is impossible for the leader of an expedition to do anything unless he has the full support of all the members of the expedition. I have had that the whole time, and am very grateful indeed for it.

The PRESIDENT: I do not quite know whether to be grateful to Professor Debenham and to Dr. Longstaff, or whether to complain that they have said what I was going to say. I think we are all agreed that this expedition is an admirable answer to those who talk nonsense, as I hear people talk and see them write, about the decadence of modern youth. I would seriously say that I am not entirely in agreement with Dr. Longstaff when he says that Mr. Roberts very wisely left out the more scientific part of his lecture. We should have been very glad to have heard, as we shall be more than glad to read, of the more scientific part of the work done up in Iceland. I also have read Mr. Roberts's lecture and look forward, with immense pleasure, as I am sure many do, to all the various collections, and both Professor Debenham and Dr. Longstaff have spoken of the appendices which will come out.

I would emphasize all that those two more senior men have said in their knowledge both of Oxford and Cambridge expeditions. My knowledge is more extended, I will not say in the world, for they are both great travellers, but perhaps among the youth that goes out to do this sort of work; and we have had an admirable example of the work which they are capable of doing. You may be

quite sure that we shall always encourage to the full the work which is done by the more junior members of the community in the way not only of "discovery and exploration," as we say on the back page of the *Journal* (incidentally, it is proposed to add to that, "research in all branches of geographical interest"), but of the research which comes afterwards and adds to the interest and good of the human race.

Not only would I, on your behalf and on behalf of the Society, thank Mr. Roberts and all his companions for the admirable work they have done, but also for the very modest way in which you, Mr. Roberts, have described it to-night. I know that I have said often before, and I have every intention, if occasion offers, of saying it again, that we in this Society realize to the full the difference between leader and any other member of an expedition. The thanks and gratitude which Mr. Roberts has given to his companions are very well merited, we know; but it is only the leader of an expedition who can say "Yes" and "No." With that in our minds, Mr. Roberts, we thank you most sincerely, both for your work and for the way in which you have described it.

Note on the map.—The main features of the map of Vatnajökull have been taken from the maps of Iceland by Thoroddsen (see p. 289, note 1) and Bruun ("Översiktskarta Island," published by the Society "De Danske Atlanterhavsöer"). The south coast and southern margin of Vatnajökull are taken from the maps of the Danish General Staff: the position of the northward extension of Kverkfjöll from Trautz's survey (see p. 289, note 2); Reck's sketch-map of the north-west has also been used ("Glaziologische Studien über die rezenten und diluvialen Gletschergebiete Islands," *Zeitschrift für Gletscherkunde*, Bd. V, 1911). These works have been summarized by H. Wadell in 1920 (see p. 290, note 1), whose map has here been further improved upon. The form lines in the centre of the ice-cap are based upon barometric readings in combination with compass bearings and distances recorded by the sledge meter.

THE NAMULI MOUNTAINS, PORTUGUESE EAST AFRICA:

A paper read at the Evening Meeting of the Society on 20 February 1933, by

J. VINCENT, M.B.O.U.

PORTUGUESE EAST AFRICA, or, as it is more correctly termed, the Colony of Mozambique, was one of the few ornithologically unknown corners of Southern Africa, and when in the summer of 1931 it was made possible for the British Museum to carry out a preliminary survey of that territory, I was asked to make the exploration.

Mozambique Colony has as its northern boundary the Rovuma River at lat. 10·40° S., and as its southern boundary the confluence of the Pongola and Maputo Rivers at lat. 26·52° S. The western frontier is an extremely broken line with its outermost point at Zumbo on the Zambezi, so broken that the width of the territory varies between 31 and 718 miles. On the landward side the whole colony is bounded by British territory, except on the north, where it runs with the mandated Tanganyika. The coast-line is about 1500 miles long with important ports such as Lourenço-Marques, Beira, and others, also innumerable fine natural harbours, among which are those of Mozambique and Pemba Bay at Porto Amelia. I think that I am correct in saying that the last named is about the third largest natural harbour in the world and has deep water close inshore. The total area of the Colony is 310,000 square miles, almost four times the size of Great Britain. The population is about 3,666,000, thus giving a density of nearly 12 to a square mile. The whole colony is roughly in the shape of a clover leaf pointing to the west, with the Zambezi River forming the vein of the centre petal.

Before leaving London it was understood that I should carry out a review of the avifauna of the country, to determine any probable geographical variations of birds and to define the demarcation between some South and East African bird forms. In this connection we can see how geography affects natural history, for the geographical distribution of birds gives rise to many complex problems of ornithology. In Africa we find a number of features such as mountains and escarpments which split up many species of birds into quite distinct races; prominent examples of this are seen in the Muchinga escarpment of Northern Rhodesia, west of the Loangwa Valley, and in the "island" mountains of northern Tanganyika. In East Africa we have had in Tanganyika Territory bird forms varying widely from others farther south, and, for many years, the Zambezi River has been accepted as an adequate demarcation. But it has been long evident that something more accurate was wanted and that it was to be sought for in Mozambique.

The surface of the colony is broadly divisible between the coastal lowland, the middle plateau, and the high plateaux. The first has an extreme altitude of 500–600 feet, but is mostly much lower. The middle plateau or shelf, up to 2000 feet, has a gently undulating surface, frequently broken by island hills. The mountains are widely separated, and north of the Zambezi we find only two mountainous features of any importance. To the west of the Lugenda River and east of Lake Nyasa the plateau rises from 1100 feet to 6500 feet,

and forms the Mesenga Mountains. In the districts or provinces of Quelimane and Mozambique the lowland is broken by abrupt eminences, forming a chain of intermittent peaks or hills, among which the Namuli Mountains reach an altitude of nearly 9000 feet; this high ground seemed to be the only geographical feature which might have some influence upon avifaunal distribution. Accordingly the plan formed was to confine the explorations to the half of the colony north of the Zambezi, and to collect north and south of the island mountains and to some extent upon them. When the collections have been worked out I think it should be found that the assumption was correct, and that whereas South African birds extend north of the Zambezi, those found north of these hills more nearly approach Tanganyika forms. The value of such a discovery lies in the definite narrowing down of the areas wherein affinity between distinct forms exists, and there will be some important overlapping and intergradation of characters to note. By this intergradation some hitherto dubious subspecific relationships will have to be accepted in a general way as proved, and some differences of opinion, based on various postulates, will have to be sunk. Not that there is any real principle in such proofs, as is shown to us in the "Formenkreise Theory" of Kleinschmidt.

One reason for exploring the Namuli Mountains in some detail was that many of these high and isolated peaks have distinctive forests near their summits. Collections made from mountains at the south-westernmost end of this chain, and in Southern Nyasaland at Mlanje, show that these forests possess a very interesting and distinctive flora and fauna from the adjacent country. It was of considerable importance to explore other patches of similar vegetation in Portuguese territory, with the idea of ascertaining what distributional affinity exists between these isolated knobs. Although many peaks of sufficiently high altitude to hold the necessary forest are known from maps to occur in Mozambique, we soon found that a number consisted of tooth-like crags of practically sheer rock, almost unscalable and possessing little or no vegetation. It was decided therefore to make the longest camp at the highest point, namely on the Namuli Mountains.

We spent some months wandering about on the lower Zambezi and away up through Southern Nyasaland into Angoniland; an extensive collecting journey had been made from Lake Nyasa across due east to the coast; thence through very little known country right up to the Lurio River mouth and in the vicinity of Porto Amelia. This had been a great success from the bird point of view and the journey was full of interesting incidents. In July 1932 we made up our minds to proceed without delay to Namuli. Leaving the Lurio River we headed southwards, passing through the growing port of Nakala, whither it is rumoured the capital of Mozambique may be moved from its present overpopulated site on the small island of Mozambique; thence westwards, leaving the coastal belt for the central plateau. The journey was not without its diversions, for on two occasions the lorry transport fell through flimsy bridges and hills were not infrequently encountered on apologies for roads, so steep as to entail a complete unloading.

As we climbed back on to the higher ground of the interior it was a pleasant thought to know that we were leaving the worst of the fever country behind us. All of Portuguese East Africa has had a bad reputation for unhealthy

climate; hence perhaps the paucity of natural history exploration, but it is not generally as bad as it is painted, although blackwater and malaria are both very prevalent in a great deal of the country investigated. Our original intention was to carry out the expedition with porters on safari, but this proved quite impracticable over extended periods, on account of the extent of the baggage and the scarcity of food in many districts and the consequent difficulty of obtaining rations for a large number of bearers.

Most of our route lay through the woodland monotony which clothes the greater part of the central plateau, and it is similar to that found throughout Northern Rhodesia, Southern Belgian Congo, and many other parts of tropical Africa. This woodland or open forest consists of *Leguminosae*—principally *Brachystegia* of many varieties, with *Pterocarpus angolensis* very common and the ubiquitous *masuku*. The last named is a widely used native term for a tree which I take to be a form of *Ficus* having edible fruit. We were also passing through what is without doubt some of the finest game country in Africa, constituting a paradise for the big-game hunter who does not mind the risks of a bad climate and who secures the necessary licences. The following is a list of the fauna which I could find within walking distance of one of many camps: elephant, rhinoceros, wildebeeste, sable, eland, hartebeeste, reed-buck, hippo, crocodile, lion, hyena, and many smaller varieties of mammal.

The day before reaching the base camp from which operations on Namuli were to be worked, we halted early in the afternoon, having secured an eagle and some crested guinea fowl (*Guttera*) on the road, which had to be preserved—and a very ill-chosen camp it proved to be. Not only were tsetse fly bad, but we were raided at intervals from sundown throughout the night by a couple of lions which proved too elusive for an effective shot, although I had a spotlight, principally because they were aided by the long dense grass all around us. We heard the next morning from a Portuguese official near by that these two lions were confirmed man-eaters and had had twenty people in twenty-one days. Portions of Portuguese East Africa are probably unique in the number of lions to be found therein and certainly unique in the huge percentage of them which are man-eaters. The figures representing native inhabitants annually killed are amazingly high, and the carnivora with a preference for human diet are far from being old and incapacitated lions, as is generally believed.

Eventually we arrived at the only branch of the Scotch Mission in the colony, and the only mission in the province of Quelimane. This was very conveniently situated for us, near the abandoned post of Inawela, some 40 or 50 miles from Namuli Mountain, whose bare and rounded head, or cone, of rock, when not obscured by its usual cloud, was to be seen reared above the other hills in the vicinity. Here we received much valuable assistance and advice from Dr. Stoker, the resident medical officer in charge, and after some delay sufficient porters were obtained for my safari to the mountain, whither no roads led.

As far as I can ascertain, the natives thereabouts are a branch of the Makuas. They certainly belong to the Lomwe tribe, whose territory is quite small, ranging from Mokuba, north to Molumbo, and east to Ribawe. The language spoken is known everywhere in the neighbourhood as the Lomwe language,

and it is quite distinct from the Makua spoken 100 miles to the east. From the traveller's point of view it is only important that he should speak Portuguese, for, unlike our administration whose officers have to learn the native tongues, the Portuguese insists on the native learning his, and one can invariably find a native here and there who can talk Portuguese excellently.

On July 18 we set forth, forty-two bearers each carrying a load, plus his food for two days, various camp followers in the shape of odd boys brought along by some of the porters to carry extra food of their own providing—and myself. Although Namuli forms a distinctive massif, it is not a stupendous one such as Ruwenzori. But the Namuli Peaks do form the highest mountains in this very large colony of Mozambique, and there is some interest in their never having been previously photographed. I can only trace one record of their having been investigated by a European: that was thirty-six years ago, when Mr. Last visited Eastern Africa for this Society, as you may find in the *Proceedings* for 1887. The Namuli Mountains were discovered from native reports, but not seen apparently by H. E. O'Neill in January 1882, when he heard of them as "snow-clad peaks." He reached a point near by but was unable to see them on account of cloud, and he still concluded that they were snow-clad. This was later pointed out as being impossible by Mr. Last.

During the first afternoon some 15 to 20 miles were covered, the porters strung out behind in a long line with a capitão, or head boy, bringing up the rear to press on the loiterers. One or two small villages were passed and occasional natives were met with cutting down the woodland and laying the branches in rows. These when dry are burnt and a crop of corn sown on the ash-fertilized ground. This lasts for two or three seasons, when more trees are demolished and large tracts are found to be of stunted growth, the trees having sprouted again from the old stumps. But in the main the journey was devoid of interest and had little scenic attraction in the woodland monotony, until we began to climb one of the ranges of hills, when fine panoramas were obtained over the country we had traversed. Towards sunset we were in the valley of the Molokwe River, which has its source close to Namuli, and camp was pitched, the porters building a rough *boma* of branches around their sleeping places as a protection against leopard which abound in the neighbourhood.

The next morning an early start was made, and we continued along the base of the hills at a general altitude of 2700 feet. After three hours we crossed a pass at 3000 feet and dropped down into the wide valley of the Malema River, one of the principal streams rising on Namuli. The floor of the valley had an altitude of 2700–2900 feet, and at the head of it was the mountain, the first view of our objective. The neighbourhood was sparsely inhabited and eland seemed to be the commonest game. It was evident that the rainfall hereabouts was greatly increased by proximity to the mountain, and the march became rather laborious from the resultant grass growth which obliterated the track. In the early afternoon we reached the river, and a native met with near by showed us a conveniently fallen forest giant spanning the stream which was 15 to 20 yards wide, and we were able to effect a crossing with our collecting boxes on the driftwood it had collected. The presence of this enormous tree was explained by the fact that one finds an entirely different form of vegetation and dense

forest along the river banks. Such prolific growth is also found in the deeper ravines of the hills.

We camped that evening on a ridge at 3500 feet, and the following morning dropped down from its summit at 4300 feet into the valley of the Mihava and to the village of Maheneni at 4000 feet on the lowest north-eastern slope of Namuli itself. We arrived there at noon and made arrangements with the

Detailed sketch of the Namuli massif

headman to supply the necessary manioc and beans for the porters. An extensive halt was made to permit of cooking, during which time I found considerable amusement in watching a draughts-like game played by the natives in this country with stones in holes in the ground. After the meal fresh difficulties arose in the form of a strike by my porters, who considered apparently that their work was completed on arrival at the base of Namuli. The spokesman put forward various excuses as to the weight of their loads, inability to climb

Ile mountain, 50 miles south of Namuli: formation typical of the district

Characteristic view of the foothills of Namuli and surrounding country

Looking south-west from the Murukuni ridge towards Pilani and Peseni, the two lesser peaks of the Namuli massif

Northern end of the knife-edge Murukuni ridge, 6500 feet high, at its junction with the sheer face of the main peak

Northern end of the knife-edge Murukuni ridge, 6500 feet high, at its junction with the sheer face of the main peak

higher on account of the cold, and so on. In spite of being many miles from alternative assistance the only course was to sack them all forthwith, and I found myself with my five original servants and the three capitãos. We moved the baggage some distance from the village and pitched a camp. After a night of some speculation the delinquents signified their surrender in the morning by a unanimous wish to be signed on again, and we commenced our climb with the local headman, or *mwenu*, as guide.

We wound up the north-eastern slope, which is of grass dotted with protea bushes; at 4400 feet we seemed to be at the limit of the grass slopes, and entered a heavily forested gully. At 4900 feet we came out on to an isolated ridge called Orere, beneath the southern face of the main peak with its double crest mentioned by Mr. Last. Beneath was another heavily forested gully with glimpses of the Nanchili River plashing down from its source. The view was very different from that expected from previous experience with Mlanje, which has precipitous cliffs on all its sides. Here we had a succession of buttress slopes radiating down from the main peak, intersected by deep ravines whose sides were clothed in dense rain forest. Actually however the sides of Namuli massif are more precipitous everywhere except on this one face which we had so fortunately encountered. Nevertheless I was disappointed to see no evidence of the flat plateaux so characteristic of Mlanje Mountain, although we found them later on.

On Namuli only the very lowest slopes are inhabited by the natives, and where we were at nearly 3000 feet there was no sign of human habitation, and with the exception of wild pig tracks no paths were evident. After dropping down into the Ukusini forest there were signs of an abundance of the mountain forest bird life, and in the apparent absence of plateaux it seemed unnecessary to climb higher, and camp was made in a small forest clearing at 4600 feet. The porters were dismissed and given food for the journey back to their homes, also instructions to return to Namuli, to transport the expedition back to the mission as soon as a runner was sent to call them. Apropos of the strike of the previous day, it was amusing to see every one of the porters step forward when I asked for two volunteers to remain in camp for the whole three weeks, thus entailing a drawing of lots. We remained in this encampment throughout our stay, each day climbing 2000 to 3000 feet, investigating the forested ravines, bracken-filled clearings, rock slopes, or boggy plateaux.

As far as my own interests of the time were concerned the entire place proved a naturalist's paradise. Each day produced specimens of many rare species, some hitherto known to the world by a mere one or two examples, others entirely new, such as a handsome little forest warbler and a bulbul from the darkest recesses of the valleys. The preservation of the specimens was not simplified by the heavy rainfall which, to a great extent, counterbalanced the pleasure of our stay. The date of our arrival was July 21, and the weather, so perfect during our march, became most unpleasant. Rain fell in torrents that night, and the tents, which had now seen three tropical seasons and much hard wear, were soon leaking merrily; it continued with scarcely a break for three days and was followed by showery weather, and it was not until July 28, a week later, that much of the bedding and equipment could be dried.

In the surrounding country the dry season was now at its height, for very little rainfall takes place in Mozambique from May to October inclusive. But, from my experiences in July and August, and from the appearance of the vegetation which is as luxuriant in every way as at Mlanje, it is evident that the rainy season is much more prolonged on Namuli and extends intermittently throughout the year.

The rainfall is very variable in the district by reason of the disfiguration of the country. I had not the opportunity of taking rainfall measurements myself, but have obtained figures from some outlying administrative posts which were taken over periods of three to five years and may form interesting comparisons. The average annual rainfall at Ribawe, 90 miles to east, is 39 inches; at Malema, 30 miles to north-east, 40·4 inches; at Ile, 60 miles to south, 47·1 inches; at Alto Molokwe, 50 miles to south-east, 54·3 inches; and at Inawela, 30 miles to south-east, about 60 inches; at Gurue, 10 miles to the south of the peak, it must be about 70 inches; whereas on the higher slopes, as on Mlanje, it is doubtless between 110 and 120 inches. It is also of interest to find that Inawela, which, although 30 miles distant, may still be said to be among the hills surrounding Namuli, has its rain more proportioned throughout the year without the distinct dry season.

It was bitterly cold during our stay, but more in comparison with the plains to which we were accustomed than in actual temperatures, which during the period were 62·8° average maximum, and 46·8° average minimum. The average temperatures for the neighbouring places, already quoted for rainfall, during the same winter months of July and August are: Alto Molokwe, 65·5°; Ile, 67·6°; Malema, 68·4°; Ribawe, 68·5°; and their average annual temperatures are 72·3°, 74·3°, 75·2°, and 75·9° respectively. The extremes of temperature during the day throughout the year at Inawela are 65° and 96°. Mr. Last says: "On August 25 at our camp at the foot of Peseni at 4 a.m. the thermometer was at 26°, and as September is the beginning of the hot season it seems probable that strong frosts may be experienced on the mountain during the cold season." But I do not consider that the temperature falls very often below the figure he quotes: I was there in July, which may be considered as one of the coldest months of the African winter, and I should very much doubt whether the reading would have been so low during my stay even 1500 feet above my camp, where Mr. Last spent his coldest night.

Namuli's peak is situated at lat. 15·20° S. and long. 37·04° E. The sketch-map of the mountain will be found to contain a number of pleasant native names derived from old inhabitants. It is only a sketch-map, and although probably very nearly accurate as to the northern section of the 8-shaped massif, I do not vouch for the southern portion as time did not permit of my exploring there. At least it gives a very good idea of the conformation and provides more detail than any previous records. The massif is mostly limited by very steep cliffs. On the western flank of the peaks Pilani and Peseni we have a small level plateau at 6200 feet, the two peaks themselves rising to near 8400 feet. This section of the mass is separated from Namuli proper by a deep valley, whence the large Malema River rises. Beyond it is another plateau, also at 6200 feet, and to the north are the main peaks of Namuli, rising to nearly 8900 feet, flanked to the east by their buttress ridges. It is with this section around the

highest peak that I am dealing principally, for ample collecting scope was found in its deep ravines.

The Namuli Mountains form the centre of the principal watershed of northern Portuguese East Africa, and from it rivers flow north, south, and east. Mr. Last traced the Lukugu River, now called throughout the country the Licungo, to its headwaters in a small plateau on the western side of the Pilani peak. The sources of some of the principal streams on the eastern side which I traced may be of some interest, in that they constitute the chief supply of the large Malema River which flows east and north to become eventually the River Lurio, one of the largest in the country. The Malema itself has its headwaters in the deep valley separating the main sections of the massif and in streams which flow down from the north-eastern face of the peak Peseni, and the southern face of the crag Iko. Its chief supply is the Nanchili River, which rises in the head of the Ukalini forest in the deep fissure immediately beneath the eastern edge of the Murukuni Ridge. The Nanchili in turn is fed principally by the Khurukani and the Mutchoro. The former rises from the fissure beneath and to the north of the saddle connecting the two minor peaks, Mutchoro and Iko, and the latter at the junction of Mutchoro with its spur, the Ethupa ridge.

The correct spelling of the native names was provided by a native of the district who had learnt to speak and write Portuguese and who was the capitão in charge of my porters.

I did not trace the Mihava River which flows past the village of Maheneni and which must rise somewhere near by on a low spur to the north of the main peak, but it is fed by two streams from Namuli. One, the Riyasuli, originates in the small flow of water from the indent between the main peak's two crests, and drops into the fissure between the main face and the small head reared up close to its eastern wall called Thathamukacha; the other, the Napuesa, begins as a number of tiny independent streams trickling down across a smooth open ledge of rock beneath a small patch of forest on Thathamukacha's eastern face. There are innumerable small waterfalls of ever-changing beauty, for, owing to the rapidity with which rain water flows off the smooth rock faces, a storm quickly transforms a pleasant murmuring of waters between banks of ferns of many varieties into a roaring cataract unapproachable in its fury.

The points of interest to be enlarged upon are: the Muretha plateau; the strange Murukuni ridge, a knife-edge connecting the crag Iko with the final 2000 feet of almost sheer rock of the main peak; and the vicinity of the Ukalini and Ukusini forests below. Gurue is the only point near to the mountain inhabited by Europeans, for it is a small Portuguese administrative post. This is the former site of Chief Gurue's village, where Mr. Last made his encampment in 1886. The heavy rainfall has prompted the establishment of the first tea plantation at this spot, and it promises to be as successful as Nyasaland tea near Mlanje.

I spent a short period at Gurue late in January 1932, when it had been my intention to explore Namuli Mountain at the commencement of the expedition. But it proved quite impossible to think of climbing to the higher altitudes at that time on account of the prodigiously heavy and almost daily rainfall. After several days collecting around the base of the mountain where the luxuriance

of the undergrowth proved a serious drawback, we had to abandon the attack on the massif and proceeded westward over waterlogged roads and swollen rivers. Namuli Mountain may be approached by recently constructed roads from two directions. From the west the road leads from the southern Nyasaland border at Mlanje through Portuguese Milange to Mokuba, 143 miles. Thence it proceeds northward through Ile and Lua to Gurue, a further 128 miles, where one is near the southernmost point of the massif. From the east the road runs from Mozambique, or more correctly speaking, from Lumbo or Mossuril, on the mainland opposite to Mozambique, to Nampula, 114 miles, thence through Ribawe to Malema and southwards to Inawela, another 182 miles. From this point a journey across country similar to mine has to be made, unless one is prepared to travel another 195 miles southwards to Alto Molokwe and so to Ile and Gurue on the first-mentioned route.

The Muretha plateau was reached by climbing the dense vegetation-filled valley of the Mutchoro stream. The principal form of undergrowth met with on such a climb, covering the entire ground around the forest edge, is a mass of ginger-lily, as it is commonly called; actually it is a form of ginger *Kaempferia aethiopica*, whose flowers appear before any foliage, growing out of the ground like mauve crocuses. Creeping everywhere, and amongst it, is an unpleasant thorny creeper, *Smilax kraussiana*. The route occasionally led into the semi-gloom of the forest, where photography was difficult. Even in the open a cloudy sky was almost general after 9.30 or 10 a.m., when clouds collect around Namuli's heads. Within this forest the foliage remained perpetually damp, and every branch or liana touched sent down a shower of drops.

The last 100 feet or so up Mutchoro was rather a scramble, and near the summit some picturesque although common tree ferns were passed, but at 6200 feet the level plateau was before us, quite a mile in width, and strangely like the Lichenya plateau of Mlanje, where I spent the previous Christmas and which is at a similar altitude of 6300 feet. The whole consisted of a rolling short grass flat dotted with patches of thick forest, the trees mainly similar to those found in the ravines but not attaining such great heights. It appeared as though walking on the plateau might be pleasant, but actually the grass seems to be underlain by a black soil more in the nature of a peat bog, a little over a foot in depth and perennially waterlogged. Everywhere it is somewhat shaky, and in places one stumbles off grass "tumps" up to the knees in concealed waterholes. Among the grasses grow several varieties of "everlasting" flowers: *Helichrysum*, a prominent one, which is probably new to our knowledge of tropical Africa, has thick grey leaves and yellow flowers. There are also a few ground orchids and a form of gentian. Within the forest patches the undergrowth is a soft weed 4 or 5 feet high, a form of *Vernonia*, also thought to be new. I saw no specimens of that fine timber tree the Mlanje cypress (*Widdringtonia whytei*), only known to exist on the mountains of Mlanje in Nyasaland and Chirinda, in Southern Rhodesia. On the Muretha plateau also I saw no traces of any bauxite deposits such as are characteristic of the plateaux, notably the Lichenya, on Mlanje Mountain. With my negligible knowledge of geology I fully expected that this source of aluminium would exist on Namuli, in view of the considerable affinity in many respects between the two massifs. More especially did I expect to find it on the Muretha plateau,

The double-crested peak of Namuli from the Orere ridge

The Muretha plateau, 6200 feet

Slopes of Namuli at 5500 feet

Looking across the Ukalini forest to the rock walls of Namuli

because it was not fissured by any valleys and there seemed little possibility of any deposit having been eroded from such a level plain. But it must be admitted that with the exception of this one plateau, the broken character and numerous buttress slopes form the most striking feature of Namuli's eastern flanks, and they must surely prove that its erosion and exfoliation have progressed much more rapidly than is the case with the Mlanje massif.

Before going on to a description of the Murukuni knife-edged ridge I will briefly describe some characteristic habits of the natives, noticed during my wanderings around Namuli's base. The severity of the climate no doubt keeps the natives to the lower levels although, on the other side of the mountain, I heard of some villages up near the source of the Licungo. Mr. Last heard of these also, and was told that the inhabitants were cannibals, but it is unlikely that any cannibalism is practised to-day. I met native hunters trapping at higher altitudes, and one frequently sees them with their nets and decoy birds used for the snaring of the partridge-like *Pternistis*. It must be remembered that this country is far from being opened up, and were it not for Gurue, with its handful of Portuguese, the entire district would be untouched by Europeans. The natives require nothing from the outside world, the inevitable trading store has not reached here, there are no exports, and they are essentially a primitive people with agricultural pursuits, and no intertribal fighting as of old. The soil is of no great fertility except along the river valleys and on Namuli's lowest slopes, and in the main a native garden is worked out in three years, after which a fresh patch of ground is cultivated.

The staple food is kafir-corn, *mopira*, as it is called here, and *amabele* in South Africa. It is a form of millet and the head is cut off when nearly ripe, dried, threshed with a stick, and ground into flour by pounding in a mortar, and finally by rubbing with one stone against another. In the field work the labour is shared equally between the sexes, unlike many other parts of Africa, where the greater part of the toil is done by the women. Maize is very little grown; it is probably of recent introduction by the European and its value not yet realized. Most of it is eaten green on the cob and so little is dried for flour that granaries are not built and it is merely hung in bundles on poles. The villages are characteristic in having many huts with open sides, outside kitchens actually, where the greater part of the day is spent and most of the meals are cooked. The method in common use of making fire is to have two twigs, one fitting into a hole in the other. That with the hole is held to the ground by the feet and the other is quickly revolved between the palms of the hands; a little heap of charcoal soon collects on the piece of dry bark placed beneath, and can be blown into flame soon after it has commenced to smoulder, which is within a minute or two.

Other crops grown are a very small millet for beer, and kasava or manioc. The latter is grown mainly as a standby, and as luxuries we find sweet potatoes and beans, usually tree-beans. All forms of flesh are eaten when opportunity occurs, even rats, mice, snakes, and dogs. Rice is liked best of all, but is grown only in a few districts. Salt is the principal requirement from outside sources, and quantities of supplies such as flour, eggs, and fowls can be purchased for a few spoonfuls of this commodity.

Around the fields one sees small thatched watch-towers, huts raised off the

ground on poles as a protection against predatory mammals, where the owner beats a gong to scare wild pig from his crops and to keep an eye upon designing neighbours.

The natives manufacture their own cloth. There are many suitable trees, and a 4-feet-long section is cut from a sapling of about 3 inches diameter; from this the hard shell of the bark is scraped, after which the pole is beaten with a piece of wood to loosen the bark. A longitudinal cut is then made and the whole of the thick bark is eased away from the pole, giving a strip 4 feet long by about 12 inches wide. This is scraped again to make it slightly thinner and soaked for two days, after which it is pounded out with an ebony wood mallet to a finished strip about three times its original width. Some ingenious little bark sacks are also made for the transportation of rice, beans, meal, and so forth. In order to obtain one of these the outside shell of the bark of a tree is scraped off and a slit made round the entire circumference; the bark is eased slightly away from the wood beneath the cut and earth is packed into the space with a stick; more and more packing is added, the fibrous bark stretches outwards and extends gradually downwards until the required length is reached. The bulged portion is then cut and slipped off the pole, its base is tied together, and the result is a soft red-brown sack usually of about 12 inches inside diameter. The women wear a rough strip of this bark cloth as a skirt, whilst some of the men wear "pullovers" of the same material with another piece as a small round cap, and anything more like Robinson Crusoe cannot be imagined.

Another interesting custom, now rare in Africa, but occasionally met with here, is iron smelting. Clay pipes are first made by plastering clay to a smooth pole which is subsequently drawn out from the covering. Four of these are generally used, sunk into the ground to provide draught for the furnace. This consists of a bowl-shaped hole dug into the ground with the four pipes leading into its base. First of all charcoal is put in, then the iron ore, which is dug up in many places, more charcoal fills the hole and a clay lid is plastered on, leaving a small vent. The bellows are antelope or goat skins with their necks tied to the ends of the pipe projecting above ground; they are mere open bags and draught is supplied by quickly opening and shutting them by hand. The operation is about 2 per cent. efficient, but after nearly nine hours the entire cavity is at white heat and the iron sinks to the bottom. The village blacksmith hammers out spear-heads and garden hoes with this material.

Now to return to the mountain and the Murukuni Ridge. To reach this we followed the Nanchili stream, passing quiet pools within the forest with moss-covered rocks, about which pretty little mountain wagtails (*Motacilla clara*) were flitting and running. Such streams rise with incredible rapidity after rainfall. A fine waterfall was met with, flanked by enormous trees, and a number of samples of their foliage were brought back, but many remain unidentified and are probably new.

Mr. Last mentioned in his paper that the whole side of the mountain was covered in dense vegetation in which large trees, vines, tree ferns, palms, bamboos, and so forth all combined to add beauty. I saw however no trace of any bamboos whatsoever on the eastern face of the mountain, neither were any to be found for some considerable distance to the east of the massif along our

line of approach. On this point I am quite confident, because bamboos are an essential for the field ornithologist, although of course some other twigs can be utilized, because in the preparing of good bird skins for museum specimens one invariably inserts a bamboo twig into the artificial body of the bird, reaching from the base of the tail to the base of the skull. As my supplies were getting short we made exhaustive inquiries as to the whereabouts of clumps of bamboo, and we were assured by many natives that there were none in the district and, finding none for ourselves on the mountain, we were compelled to extract bamboo rods for our needs from the poultry crates we had brought with us. Mr. Last may have discovered some on the southern face of the mountain, but I cannot recollect having noticed them there when I was at Gurue for some time during the preceding January, as I have already mentioned. Yet some distance away, in the country to the southward, notably towards the administrative division of Ile, bamboos are of common occurrence in the woodland. Mlanje Mountain differs in having vast patches of bamboo, forming a prominent feature on many slopes, especially near 5500 feet altitude. These bamboos, or certainly those at Ile, seem to be *Oxytenanthera abyssinica*.

In one glade a fine Bar-tailed Trogon (*Heterotrogon vittatum*) was shot, and as I rushed forward to secure it I nearly stumbled upon a leopard lying beneath a large rock. It made off, luckily for me, as I had only dust shot and a 0·410 bird gun to argue with. Leopard are very common on the mountain and there are amazing numbers of wild pig, but I saw no trace of the bushbuck one might have expected, nor of any other game on the mountain itself.

Up on the higher slopes erosion had rendered the soil poor and scanty: they consisted mostly of rock damped by trickling moisture upon which the footholds were scattered tufts of grass with tiny clumps of moss and flowers, white *Crassula*, and small blue *Lobelia* plastered on the rock. The general cloud level seemed to be about 6000 feet, and nothing could be seen of the shrouded peak. Passing another forest patch we were at 5800 feet and on the last rock slope before reaching the knife edge. A common plant growing among the rocks was a tree lily, a form of *Vellozia*, not yet identified. The natives call this *chau* and use a piece of the fibrous stem as a tooth-brush or tooth-pick. From this slope a fine view was obtained down into the Ukalini forest 1000 feet or more below, and across to the sheer face of Namuli's peak.

Although a height of about 7200 feet can be reached with comparative ease on the crag Iko facing Namuli, and although I attained a height of 6500 feet on the Murukuni ridge without any difficulty whatsoever, I did not climb to the summit of the main peak; neither was any attempt made to do so, as it could not have possibly led to any additional results of ornithological value. The northernmost end of the Murukuni ridge leads to the face of this perpendicular mass of the rounded cones, and I formed a similar conclusion to Mr. Last, namely, that they appear inaccessible. Not an opinion that would be endorsed by some rock climbers, perhaps, but nevertheless the smooth wall did not seem to hold forth many possibilities, and although there was a chimney here and there caused by the wearing of a particularly deep fissure, they did not continue to any great height towards the summit.

In this connection another interesting comparison with Mlanje Mountain may be made. Certainly the attainment of Namuli's summit would be a very

different proposition to the scaling of Mlanje's 10,000-feet peak, which has been accomplished several times. For there on Mlanje, although it is less than 100 miles away in a direct line, the cone-like formation so common in the Namuli district is quite unapparent, and the main peak is rough and deeply fissured. Another feature remarked upon by Mr. Last in 1886 was the evidence of a patch of trees near the very summit of the main cone. This is still apparent, especially one lone tree which stands out in an incongruous fashion on the sky-line. It must be a large tree and it is a matter for some conjecture how it manages to eke out an existence on a slope from which all traces of soil must have been long eroded (or so one might reasonably expect). This particular tree gives some idea of the enormous height of the final wall of rock, for its precipitous sides are most deceptive and do not appear to be even 2000 feet in height and certainly not 2500 feet, which must be nearer the actual altitude.

This last 2500–3000 feet of the rounded head is an almost perpendicular mass of pale grey stone. The main peak or head seemed to be grey biotite granite and the structure of the mountain appears to be that the great domes are of granite and that they are flanked by gneisses, on which the plateaux may be reasonably supposed to rest. It is everywhere guttered longitudinally by the wear of generations, and I think that the many streaks are mere colour changes due to weathering.

Then we passed on up to the Murukuni ridge, where many views were obtained, and to the south-west were the peaks of Pilani and Peseni flanked by another small plateau at 6200 feet. The ridge is the strangest formation that I have seen in this part of Africa. It connects the crag Iko with the main face of Namuli, rises gradually from 6300 feet to 6500 feet, and forms an amazing walk along a narrow table, for it quickly narrows down from a few yards to a few feet in width. On the east one looks down at least 2000 feet into the Ukalini forest, and on the west down 3000 feet or more into the plains, with streams like narrow ribbons and natives like slowly moving ants. At the northern end it is only just wide enough to walk upon, and the one native who had accompanied me thus far positively refused to budge any farther. The next time I came up to the ridge the clouds arrived before me, and as I walked gingerly along the crest the eastern valley was full of vapour which, blowing over, limited the visibility to a few yards, and the only sign of life was a large raven which drifted past close to my head to disappear in the mist.

On August 10 our stay was at an end, and every one of the porters arrived to take us away. The last night was cold but clear, and our previously quiet camp was lit up by a dozen or more twinkling fires with the men singing and talking round the blaze. The time had been spent very profitably from the point of view of our collecting. A very representative list of the birds of the mountain had been compiled, and I am confident that there cannot be very many additions to be made. It remains for a resident ornithologist, if ever there should be one, to complete the list by recording migratory birds and other occasional visitors, but we had recorded sixty-eight different species above 4500 feet altitude, of which fifty-three were represented in a collection of roughly 250 skins. In addition a number of rare small mammals were secured, and the results were very fair considering the prolonged conditions adverse to both hunting in the

forest and the preservation of specimens obtained. The collections are now housed at the South Kensington Museum, but the birds have not yet been fully worked out, and the mammals still remain unidentified.

Camp was struck the following morning, and we started off after some delay, occasioned by my poultry yard of spare hens for the table having strayed into the forest. They defied the searching of fifty odd natives, and we left word that the local chief could have them as a present when they put in an appearance. This chief had paid a visit to our camp bringing the customary present of fowls and vegetables. These gifts are rather amusing, as one is always expected to pay for them in cash or kind, in other words, it is an exchange of presents, and, as it is an insult for the initial gift to be refused, the humour lies in the custom being used as a profitable excuse for the local potentate to palm off his oldest hens on the visitor.

We made a fast march back to our base at the mission and arrived on August 12. Two incidents of the road may be mentioned briefly. When we passed a chief's grave, the villagers were persuaded to open up the fence surrounding it in order that a photograph might be secured of the stool and earthen pots of beer and food placed alongside the mound, which are periodically replenished for the use of the deceased. This was not the only place where such pots were put out to appease the requirements of departed spirits, for a number of times we came upon a small group of earthenware vessels on the ground away in the open forest or woodland, and the explanation of their purpose provides another reason for the repeated depredations of man-eating carnivora. Where I saw them they had been put out to satiate a man-eating leopard which had killed several children in the district; fortunately it is much more uncommon for a leopard to adopt humans as prey than for a lion, because it proves invariably to be a great deal more daring and cunning. The natives were firmly convinced that the leopard represented the reincarnation of a departed spirit, and positively refused to set traps or to adopt any other plans for destroying it; instead they persisted in the placing of these ludicrous little pots along the sides of forest tracks.

At a small stream natives were poisoning fish, and pictures were taken of the process. It is a very simple one, as the leaves of a leguminous plant are pounded in a mortar and the bruised mass is fed into the flowing water of a stream. The fish float to the surface as though dead, but actually they recover soon afterwards and swim away. On this particular occasion the natives were securing fish the size of a small sardine, and although a large party of men and women thronged the narrow brook, all obtained enough fish for a meal or two.

From the mission we adopted our mechanical transport again and proceeded through Alto Molokwe and Mokuba to continue our collecting on the Portuguese–Nyasaland border, 320 miles away at Milange (Portuguese).

The Government of Mozambique is making great strides and the administrative officers recruited are of a very high type. Excellent roads are being established, and in these and the new official buildings we see an outward sign of the inner push so evident throughout the attractive Colonia de Moçambique.

DISCUSSION

Before the paper the PRESIDENT (Admiral Sir WILLIAM GOODENOUGH) said: The massif known as Namuli in Portuguese East Africa lies in lat. 15° S. and long. 37° E., and is very little known. Mr. J. T. Last, a Fellow of this Society, was sent there by the Society in 1886 to trace the course of the Luanga River. He did some valuable work, although it must be admitted that subsequently his observations were very much held in question. He was also told to investigate the Namuli Mountains as Mr. H. E. O'Neill, who was out there at the time, had been told by the natives that there were snow-capped mountains there. Mr. Last gave a description of his work, which will be found in the Society's *Journal* for the year 1887. Mr. Vincent, who lectures to us to-night, paid a visit to the Namuli Mountains in July and August 1932. The chief object of his visit was an ornithological research of the whole of Portuguese East Africa. He had good opportunity of seeing the mountains and made the most of the time he was there.

Mr. Vincent was educated at Christ's Hospital School. He has been a farmer, both in England and in Natal. He accompanied Admiral Lynes, whom we are very glad to see here this evening, on an expedition when they crossed Central Africa in carrying out their occupation of studying bird life. So that Mr. Vincent has already had a varied career. He will speak to us on Namuli in a lecture which I now invite him to commence.

Mr. Vincent then read the paper printed above, and a discussion followed.

The PRESIDENT: Admiral Lynes, both before he retired from the Navy and since, has devoted nearly all his travels to the collection of birds. I will ask him to speak to us on the subject of the lecture.

Admiral LYNES: A few years ago, as our President has told you, I had the advantage of the help and companionship of the lecturer in a tour across Central Africa, and on through West Africa. Our principal objective was to find out all we could about the different kinds of Fantail-Warblers, and to relate their distribution to the physical geography of the country. When we returned to England, I found that the Natural History Museum was looking out for some one to undertake an expedition to Portuguese East Africa, and had no hesitation in recommending Mr. Vincent as the right man for the work. So, indeed, he has proved himself to be. Of Portuguese East Africa I know practically nothing more than what Mr. Vincent has just told us in his excellent lecture. However I was asked to say something to-night about the distribution of the different kinds of birds in Africa which would relate the subject to the lecture.

It might perhaps be wondered why, if the British Museum sent Mr. Vincent out to Portuguese East Africa chiefly to collect birds, he should have taken so much pains to find out all he did about the geography of the country. Would not, for instance, a place-name and the latitude and longitude written on the label on each specimen have been sufficient? Certainly up to about the end of the last century little more than that would have been expected, but now ornithology asks for more, and I will try to explain why. There are two branches of this science which are concerned and which, for present purposes, are best considered as distinct, although they really are very much consequent one on the other. The first is the discovery of all the different kinds of birds that inhabit the Earth and whereabouts on it they live. One may call the ultimate end of that endeavour the plotting out on the globe of the various kinds of birds. That much association between birds and geography has, of course, been going on from earliest times.

At first it was thought sufficient to label specimens of birds found in strange

parts of the world with the names of continents—Lybia, Cathay, New Holland, Australia—then progressing to finer distinctions, provinces, districts, and so forth. The eighteenth century gave us the natural system of classification of birds whose framework is still used, and in that system the *species* was the unit or lowest grade. In practice, a different kind of bird was synonymous with a different *species* of bird. Up to about the end of the nineteenth century the plotting out of the various species on the globe had made great progress, and at an enormously increasing rate as travel became more and more easy. It had already been perceived that some of the species were apparently quite the same all over their ranges, and that others were not: that there were, in fact, small geographical differences—little differences of size, coloration, and so forth—among the species here and there, but little or no endeavour was made to formulate or systematize those differences until about the end of the last century. Then the matter was taken up really seriously, and geographical variety was brought into classification, which implies that the different varieties were given names of their own. They have been called geographical races or *subspecies* of their species, and their names are the names of the species with the particular subspecific name tacked on at the end. This does not in the least alter any conception of the species as a separate unit: when discussing a bird it is only necessary to mention the subspecific name when the subject requires it. So that to-day ornithologists who concern themselves with this branch of the science are continuing to plot out the different kinds of birds on the globe, only with finer perceptions than before.

Still, one may ask how even that requires any finer connection with geography than hitherto. To illustrate that it does do so, I will leave generalities and get into Africa, taking Kenya Colony as an example. When it came to plotting out the geographical species inhabiting the southern and central portions of that political division of Africa—an area only about the size of the British Isles—there were found to be a bewildering number of subspecies, some of the species seeming to have as many as five or six or even more subspecies. As plotted out on a flat map, it looked almost impossible, and as if this new refinement of classification was likely to be defeated on its own merits, as indeed had been prophesied by those who had all along been opposed to it. But now, thanks to many workers in Kenya Colony, the whole thing is clear enough and meets with general acceptance because it is seen how well the distribution marches with the physical geography of that varied territory. Thus, one may find—all of the same species—one subspecies in the coastal strip, another on the central plateau, another in the highlands, and yet another on the western slopes of the highlands, which go to contain the Victoria Nyanza, and still another, perhaps, in the upper zones of one or all of those great isolated peaks, Kilimanjaro, Kenya, Elgon, and so forth. By an understanding of the physical geography, the plotting out of the subspecies is made comprehensible and acceptable. And so it is, in general, all over the continent. Now the geographical species are recognized, there *must* be with them a more intimate association with physical geography than hitherto.

Then there is the second branch of ornithological study to which I alluded. It is that which seeks to explain these riddles of distribution: *why* there are many races, and so forth. Is this new refinement of gathering together all the relevant material about the birds and the physical geography going to help towards a solution of those wider problems of origins and causations, evolutionary or other theories concerning the creation of the great variety of animals now inhabiting the Earth? That is a question I am not qualified to answer. Perhaps a great deal more about it all will have to be found out before any one will be able to form an opinion one way or the other. So far as Africa is concerned, as a whole, the plotting out of the various kinds of birds is certainly far in advance of the kind of

knowledge of the physical geography that is required for the examination of these problems.

Portuguese East Africa has up to now been a very blank part of the map of Africa in this connection. There was a very poor knowledge of its birds and scarcely anything of what was wanted to explain the distribution of those that were known to inhabit the country. Now Mr. Vincent has brought to the British Museum a fine representation of several hundred different species and subspecies, over 2200 specimens containing examples of about nine new species and some thirty new subspecies, and specimens of birds hitherto unrepresented in our national collection, all most beautifully preserved and accompanied by the fullest information about physical geography. May we not therefore congratulate him on a first-rate piece of work, well done, and wish him equal success in similar, if perhaps occasionally more amenable, fields in the future?

The PRESIDENT: We have with us Sir Charles Belcher, who was not a judge, but the judge in Nyasaland, which is closely adjacent to the country we have heard about this evening. Among other things, he has written a book on 'The Birds of Nyasaland.' I will ask him to add a few words.

Sir CHARLES BELCHER: It has been a very great pleasure to me to hear the lecture this evening, although I confess it has made me a little homesick, not less so, because in one of the last pictures I perceived some of the gum-trees of my native Australia growing in Portuguese territory in East Africa!

I suppose you are all familiar with the saying that Africa is a country that all men love and all women hate, but I do not think that any ladies who have lived in Nyasaland can look back on it with anything but the most pleasant recollections, as I think all of us do. The country which you saw to-night so well exhibited in Mr. Vincent's pictures is extraordinarily like the strip of British territory which extends along Lake Nyasa right into the heart of the enormous territory of the Portuguese. That we have that territory, as no doubt all of you know much better than I can tell you, is due very largely to two great men: David Livingstone the missionary, and Sir Harry Johnston the administrator. The first, perhaps, was the real European pioneer of that part; the second was the man who, undoubtedly, almost through his own hand, saved that country for the nation to which it now belongs. Perhaps that has not always been recognized as fully as any one does recognize it who has studied the position on the spot and read the documents relating to what was done in the nineties as I had the privilege to do.

I went out in 1920 as Attorney-General of Nyasaland and left there in 1927 as Judge. I must say, at once, that those seven years were the happiest years of my life. It is a charming country in every way. It has many virtues of climate, and what I am saying applies equally to what you have seen to-night of our own territory, which naturally has the most interest for us. There are hot, dry, low plains, medium slopes at the 2000-feet level, and on the top, where no natives live, those wonderful plateaux, such as Mlanje. That plateau at a height of 6000 feet is now, thanks to railway enterprise and the roads built by the Nyasaland Government, available to any one who cares to go there. Two days after leaving Beira it is possible to get to the top of the plateau without discomfort, and from there one can look down on country of the delightful character which Mr. Vincent has shown us to-night. That can be done without any of the hardships which I know very well he must have gone through, as you can all judge by the pictures. On the top of Mlanje there are about seven cottages, and it is possible to go up, as I did in October 1924, and enjoy, in the centre of Africa, the delights of an English spring.

There are one or two points arising out of the lecture that perhaps I ought to mention. The first is that, whatever may be the case in other parts of Africa,

there is no question in Nyasaland or the district of any exploitation of the native. That you will have gathered from what you have seen to-night is utterly impossible. You could not exploit the native if you tried. He would simply run away from exploitation. The only persons who run any chance of being exploited are your some thousand or so fellow-countrymen who are trying hard to make a living in that country, under great difficulties, out of the production of tobacco and other crops, principally tea. They are real pioneers undergoing great hardships. No doubt many of you are relations of people in Africa and know that. It is a fact that ought always to be before the people of this country when reading or hearing about conditions in Africa. I do not know what happens in other parts of Africa, but certainly in Nyasaland the relations between white and black, whatever you may hear to the contrary, are of the very best. Throughout, the white man treats the black man, not as a black man but as a man, a man to be respected and, in his own sphere, a man who knows his own work. I have heard it said that to the African work is a supreme evil. After all, if a native can buy a wife for £5 and she can keep him for the rest of his days, there may not appear to be very much reason why he should be disposed to work. Be that as it may, all through Nyasaland the whole community—missionaries, traders, white settlers, and black natives—live in the greatest harmony.

When I saw the pictures to-night I looked back with great regret and felt I could almost pardon the lion which, during the last five days of my life in East Africa, took away my best cow 150 yards from my bedroom window. I do not know whether the lecturer was aware of it when he showed you a picture of the bush which is used for catching fish, but those of you who are dog lovers may like to cultivate that bush. The natives call it *ntutu*, and one of its great virtues is that you can make an infusion of it, put your dog into that infusion, when all the pests which beset dogs, in Africa and elsewhere, immediately disappear as if by magic, and the dog comes out in all its pristine purity.

The PRESIDENT: All will agree with me that Mr. Vincent made admirable use of his time when he was on the Namuli Mountains, and that he has given us an excellent account of his travels. I am sure you would all like to congratulate him very much on the way that he stuck to his work. After all, one does not spend fourteen months—four months at a time, very often, without seeing a white man—with the sort of climate and country that has been described to-night without possessing a great deal of persistence and resolution. We can also congratulate Mr. Vincent on the extent of his collections.

Mr. Vincent, I do not know whether you propose to go again to Portuguese East Africa or to any other place, but if and when you do, you may come here again and tell us of your travels in the certainty that you will receive a very warm welcome. On behalf of this audience and the Society I offer you most sincere thanks and congratulations upon your work and your description of it.

Dr. Parkinson sends the following note as a contribution to the discussion:

Mr. Vincent's paper on the Namuli Range in Portuguese East Africa and his splendid photographs of that hilly country recall the work of Professor Holmes and Mr. Wray in traversing the ground west of Mozambique in the company of Mr. Wayland in 1911, and especially the exceptional development of the Inselberge type of landscape they describe and figure. These "residual mountains" rise from a peneplain, that is, a plain of erosion produced during a stable period interrupting an upward movement. A sketch-map shown by Mr. Vincent suggests that a series of peneplains exists in the Namuli district, as one would expect, and the hope rises that these, if established, could be correlated in

elevation and time with those found by Mr. Wayland in Uganda. I have noted similar peneplanations in the Northern Frontier Province of Kenya, and the presumption is that they are of very wide extent. The Director of the Geological Survey of Tanganyika Territory, Dr. Teale, has recently (*Annual Report for* 1930) emphasized the "peneplanation character" as "one of the most striking surface features throughout a vast portion of Eastern, Central, and Southern Africa." The cause is all-important, and he comments on the necessity of postulating a deep-seated force which will exert a widespread upward thrust to account for the elevation of the Continent required by the observed facts. That this force was also concerned in the formation of the Rift Valleys and the associated though far less conspicuous faults towards the margin of the Continent seems obvious. Dr. Grantham's recent work on the Lupa Area shows that some lines of shear and tectonic disturbance, seen to-day as scarps, may be of extreme antiquity, the newer rift faults having had to accommodate themselves to ancient crush planes, and one is compelled to consider whether the Rift Valley is indeed due to causes which were mainly Tertiary. Dr. Holmes figures faults defining part of the Ribawe Mountains, east-north-east of the Namuli Peak, and these doubtless are part of the Rift system.

Dr. Teale claims the mass of intrusive dolerites locally distinguishing Tanganyika Territory and of middle or late Mesozoic age, as evidence of the upward force he postulates, and the present writer is convinced that magmatic movement, however caused, has been a factor in the formation of the Rift Valleys. This is wandering from the subject of Mr. Vincent's paper, but it is worth adding that Professor Adams has recently described in his 'Geology of Ceylon' the peneplanations found in that island, and that much would be learnt by correlation of these surfaces with those of Africa, if this could be accomplished, as indeed he suggests.

THE SCIENTIFIC RESULTS OF THE WEGENER EXPEDITIONS TO GREENLAND: *A paper read at the Afternoon Meeting of the Society on 12 December 1932, by*

DR. ERNST SORGE

THE Royal Geographical Society has honoured me by an invitation to lecture on the scientific results of the Alfred Wegener Greenland Expeditions, especially on the seismic measurement of the thickness of the inland ice. I accepted the invitation all the more gladly since there was friendly co-operation between the British Arctic Air Route Expedition and the German Expedition, who did their work simultaneously on the Ice Cap and in the ice fjords of Greenland. Both expeditions have suffered the same deplorable bereavement. They are deeply grieved by the deaths of their leaders Henry George Watkins and Alfred Wegener. Their fellow-workers will keep their memory green by strenuously continuing the great work of investigation that these men gave their lives to perform.

The German expedition arose out of three different projects:

1. Professor Alfred Wegener had twice been in Greenland as a member of Danish expeditions in 1906–1908 and 1912–1913. After crossing Greenland in 1913 he brought home a project to make systematic investigations of the Ice Cap and climate of Greenland.

2. Dr. Georgi, of the Hamburg-Deutsche Seewarte, had in recent years made meteorological and aerological observations between Greenland and Iceland and intended to establish a winter station on the coast of East Greenland for the purpose of clearing up the character of the winds in the surroundings of Greenland, especially the influence of the Ice Cap on the weather in the northern Atlantic.

3. In 1925 the Göttingen geographer Professor Meinardus proposed to adopt the modern experimental seismic methods for measuring the thickness of the Ice Cap.

It was only in 1929 that the preparations of our expedition were finished. I will give an outline of the work and the journeys done in Greenland. Both expeditions were under the leadership of Alfred Wegener and sent out by the *Notgemeinschaft der Deutschen Wissenschaft*, to which we are indebted for the expenses of the expedition.

In the summer of 1929 a short preliminary expedition to the west coast of Greenland was made. The members were Professor Alfred Wegener, Dr. Georgi, Dr. Loewe, and myself. Three journeys were made on the Ice Cap. We succeeded in finding a suitable way up on to the Ice Cap in the Umanak District, and tested the seismic instruments. Then for the first time the thickness of the inland ice was measured. This expedition was favoured by good luck. The popular description of this expedition was Wegener's last publication. It has the title 'With Motorboat and Sledge in Greenland.'

From 1930 to 1931 the main expedition was undertaken, consisting of twenty members. Three winter stations were established:

1. The western station on the inland ice, 1 km. from the margin at a height of 1000 m.

2. The eastern station on the coast of Jameson's Land in the Scoresby Sound.

3. The central station, the so-called Eismitte, in the middle of Greenland, at a height of 3000 m., 400 km. from the western and eastern margins of the Ice Cap, and 440 km. from Mr. Courtauld's Ice Cap station.

The central station was established by dog-sledge journeys from the west coast. The party at this station consisted of Georgi, Loewe, and Sorge.

On his return from the fourth journey Alfred Wegener died in the November

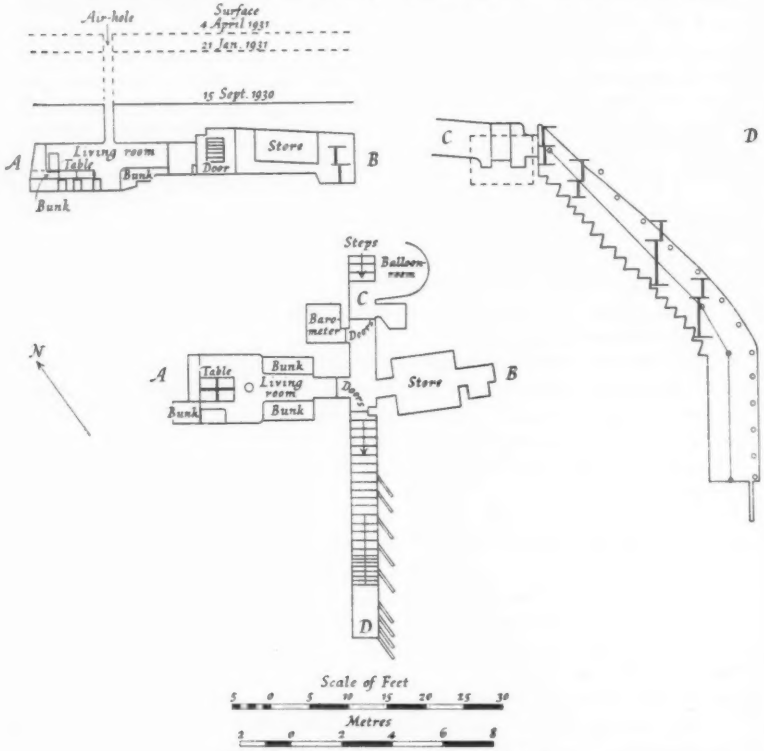


Fig. 1. Eismitte, the central station

of 1930, probably not by freezing to death but by weakness of his heart. His only companion, the Greenlander Rasmus Villumsen, did not reach the western station; he was never found and has disappeared in the inland ice.

In the summer of 1931 Alfred Wegener's brother, Professor Kurt Wegener, was sent to Greenland in order to finish the expedition.

During the winter the fate of Wegener and of the party in Eismitte was entirely unknown, because we had no wireless station in Eismitte. The party of the western station had to carry on work without their chief. I am grateful to have an opportunity to thank also in this place the members of the British

Dr. Sorge engaged in temperature-measurement at the bottom of his 16-metre shaft at Eismitte

Eismitte in July 1931: observation tower almost covered by a year's snowdrift

Wegener and Rasmus about to start on the return journey from Eismitte to the coast, 1 November 1930

Prof. Dr. Alfred Wegener

Arctic Air Route Expedition for their kind offer of sending an aeroplane to help us.

In the summer of 1931 a great many scientific journeys with dog-sledges and propeller-sledges were undertaken. The propeller-sledges were constructed in Finland. They were propelled by an aeroplane motor of 120 h.p. In the second year of our expedition they succeeded in travelling as far as Eismitte. They had a speed of 40 km. an hour.

It was Alfred Wegener's idea to introduce propeller-sledges into the exploration of the Greenland inland ice. The advantage of these sledges is that there is no danger in starting and stopping, as there is for an aeroplane. Besides, they can stand for a long time in the same place on the inland ice without needing any fuel; whereas dog-sledges continuously consume food for dogs during a stay on the inland ice. This difference between propeller-sledges and dog-sledges is very important for research work on the inland ice extending over some considerable space of time.

The chief drawbacks for the propeller-sledges are that it is very difficult and takes much time to bring them and their fuel up to the inland ice; that they cannot travel in snowstorms in conditions when dog-sledges can still travel; that the safety of travelling with dogs is greater than with propeller-sledges on account of the fragility of the motor and the body; and that the propeller-sledges are rather helpless in the regions of the crevasses but work successfully in the interior region. Maybe they will work successfully in the Antarctic.

The main results of the systematic investigation of the inland ice are the following:

1. Measurement of the thickness of the inland ice in twelve places, from the west coast to Eismitte, at 12, 42, 62, 82, 120, and 400 km. from the west coast. The thickness of the ice increases very rapidly from the margin to the interior, so that the slope of the underlying land is opposite to the slope of the surface of the inland ice. Part of the land surface in the interior of Greenland lies not nearly so high as the mountain ranges at the coasts. Certainly Greenland is not a highland throughout. Supposing measurements extended over the greater part of Greenland give similar results to ours one might compare Greenland with a plate filled with ice. The eastern edge of this plate seems to be broader and higher than the western edge, so that a greater quantity of ice flows to the west.

2. A triangulation from Eismitte to the west coast, made by Weiken, Jülg, Gudmund Gislason, and Lissey. Thus the first exact profile of the surface of the Ice Cap was measured. By repeating this work some years later it may be possible to decide whether the inland ice is decreasing or stationary. It is necessary of course to rediscover the position of Eismitte. In 1931 we built a wooden tower which on account of the annual accumulation of 1 metre of snow may be visible during the following seven years.

3. Measurement of the gravitation by Weiken and Jülg in five places: at the outer coast, near the western station, at 81 km., 120 km., and 300 km. from the margin of the inland ice. A combination of the triangulation with the measurements of the gravitation and the thickness of the ice is likely to answer the question whether Greenland is in the state of isostasy or not. All these measurements are not yet worked out.

4. At the western station and at the central station a shaft was built in the ice to investigate the physical conditions of the ice, temperatures, specific gravity, stratification, and structure.

5. The increase and ablation of the inland ice was measured from the western station to Eismitte by means of bamboo poles which were stuck deep into the ice or snow. On the edge of the inland ice 4 to 5 metres of ice melt every summer, whereas in the interior the maximum of the annual increase is equivalent to 50 cm. water at a place 140 km. from the margin and at a height of 2250 m. above sea-level. At Eismitte the annual increase is 31 cm. water. The snow limit lies on our route at a height of 1350–1400 m.

These are the chief glaciological results. As to the meteorology and aerology: On his crossing of Greenland in 1913 Alfred Wegener had recognized the difficulty of connecting isolated meteorological observations with the *réseau mondial*. Therefore he formed the audacious idea of establishing no less than three meteorological stations on one expedition: one station in the centre, two near the edges of the inland ice. The central station was to ascertain what the weather upon the inland ice really is, *i.e.* if there is in fact such a thing as a perpetual anticyclone. It was the first time that an expedition was in the middle of the inland ice during the whole winter.

Besides exploring the anticyclone, the two marginal stations had as their special object to investigate the transition from the inland-ice climate to the sea climate. At the eastern station 283 aerological ascents were made with balloons and kites by the party Kopp, Ernsting, Peters during the whole year. This ranks among the most momentous and comprehensive achievements ever attained in arctic aerial research. The meteorological observations of the three stations have not yet been worked out completely. On the whole the weather in the central station was far worse than we had expected. Frequently we were under the influence of depressions with snowstorms and overcast skies. Temperatures were very variable. The annual mean temperature in Eismitte was about −30° C. (−22° F.), the absolute maximum −5° (+23° F.), the absolute minimum −65° C. (−85° F.).

I should like to insert an example of how valuable the co-operation of different expeditions is apt to be. I am going to read a short paper by my friend Dr. Georgi, the untiring meteorologist of Eismitte.

[*Dr. Sorge here gave an account of the paper sent by Dr. Georgi which is printed on p.* 344.]

The first seismic ice sounding was taken by Dr. Mothes, pupil of the late Professor Wiechert, in 1926. Mothes was the first man to put up his seismograph on the surface of a glacier and take the measurements of the thickness of the ice. That was on the Hintereis Ferner in the Ötztaler Alpen. He compared his measurements with the borings of the German glaciologists, Blümcke and Hess, and the results coinciding the new seismic method was proved to be indisputable.

In 1929 I was made acquainted with this kind of scientific work by Dr. Mothes himself, when he made some new measurements on the Aletsch glacier, and Dr. Loewe and I had the privilege of assisting him. We then found a thickness of 800 m., the greatest thickness ever measured in an alpine glacier.

The seismic method for measuring the thickness of the ice is as follows: Fig. 2 shows a profile through an ice layer resting on bedrock. At a point on the surface an explosion is brought about to cause a sort of artificial earthquake or rather icequake. The violent motion thus produced spreads in all directions in the form of waves with diminishing amplitudes. At a distance of up to 4 km. a seismograph is placed to indicate the arrival of the waves. The registering is done by a ray of light reflected from a small mirror. This exceedingly sensitive mirror is attached to the end of a system of levers which belong to the seismograph proper. The reflected ray of light falls on a running strip of a cinematograph film. We usually employed vertical seismographs.

We had with us two apparatuses of the Göttingen Geophysical Institute and two of the famous Askaniawerke in Berlin-Friedenau. The enlargement was 30,000 to 60,000 times. The Göttingen seismographs had air damping, the Askania liquid damping. We did not take an electromagnetic seismograph, because Dr. Mothes had found in the Alps that it did not show the waves though it was more sensitive than the other apparatus. But as the time of our observations was very short, it is possible that future experiments with an electromagnetic seismograph may be successful.

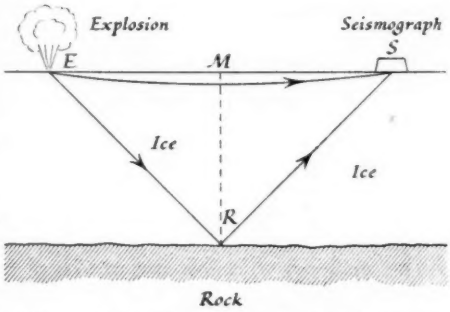


Fig. 2. Paths of surface and reflected waves

First, those waves arrive which travel the shortest distance, that is, near the surface. A little later those waves arrive which are reflected from the bottom of the ice. Another ray of light falls on the registering film writing a dotted line which serves to indicate time. Sometimes we employed an electromagnetic tuning-fork to which a small mirror was attached. The vibrations of the tuning-fork had a period of one-fiftieth of a second and were to inscribe the time-interval on the film.

Also the moment of the explosion is registered on the same film. For this purpose the plate of the seismograph is connected with the place of the explosion by a double copper wire. An electric current keeps a galvanoscope mirror in place. The explosion breaks the wire, the current is stopped, the mirror shoots out of position, and the ray of light which it reflected is displaced so that the line on the film is suddenly cut off. The whole apparatus is protected all round by a lightproof tent. In our station Eismitte we put up the apparatus in our ice cave 4 m. below the surface of the inland ice.

Usually we were two persons making these measurements, one standing outside on the ice, executing the explosion with a blasting engine (a small dynamo driven by hand), the other in the tent or in the ice cave watching the apparatus. The moment of each blasting was carefully fixed. After the icequake had been registered the film was at once developed.

We had several kinds of explosives: (1) Ammongelatine of Nobel in Stockholm; (2) a mixture of petroleum and potassium chlorate, prepared at the place of the explosion; (3) trinitrotoluol (T.N.T.).

The quantities required on the glaciers were 1 or 2 kg.; in the interior region more—often more than 25 kg. The greatest charge amounted to 73 kg. in Eismitte. These quantities are so heavy, and the transport is so difficult even by means of dog-sledges and motor-sledges, that it seems nearly impossible to employ this method to make a profile through Greenland or the Antarctic continent at small intervals.

The working out of the records is as follows:

The stretch ES is measured with a tape measure. The lapse of time between the moment of the explosion and the arrival of the waves at the seismograph can be read off the film. Therefore we know the speed of the direct waves. It is the quotient of the stretch divided by the interval of time. Supposing that the bottom of the glacier is parallel to the surface, we can work out the depth of the ice with the aid of the right-angled triangle.

Here is a numerical example: 42 km. away from the margin of the inland ice we had the following values:

Distance ES = 1858 m.
Interval of time ES = 0·536 sec. (direct waves)
Interval of time ERS = 0·883 sec. (reflected waves)

The speed of the direct waves is $v = 1858/0{\cdot}536 = 3467$ m./sec. and the path ERS $0{\cdot}883 \times 3467 = 3060$ m. Whence the thickness of the ice RM is 1214 m.

This result is likely to be right by ± 20 m.

The waves are very distinct but the amplitudes are smaller on account of the absorption of energy.

The conditions of ice measurement are in fact far more complex than the statements given above make believe. The process is evidently similar to the method of sounding the depths of the ocean by means of the echo, though it differs in various points. Reflected waves do not generally appear when the distance between the place of the explosion and the seismograph is short. Apparently in this case the greater part of the energy goes down into the bedrock so that the reflected waves are no longer strong enough to actuate the seismograph. If however the distance is about one and a half times or twice as great as the thickness of the ice, the reflections are most distinct. We have then a case of total reflection. As the thickness of the ice is unknown at the beginning of the measurements, it is necessary to make several explosions at several distances. This is also necessary on account of another difficulty.

All the waves mentioned in the numerical example are longitudinal waves. Besides these the explosion also produces transversal waves. They travel about 1700 m. a second, *i.e.* with nearly half the speed of the longitudinal waves. One must be careful to avoid a simultaneous arrival of the reflected and the transversal waves by making several explosions at several distances. Otherwise it is difficult to recognize the reflected waves. Reflected transversal waves have not been discovered till now. On the Pasterze glacier my friends Dr. Mothes and Dr. Brockamp found waves running nearly vertically down to the bottom, then under the ice in the rock and again upwards through the

ice to the seismograph. It is sometimes difficult to distinguish these waves from the others.

Now I shall point out another difficulty: The speed of the waves is everywhere the same in pure ice, but not in *firn*. In the Alps firn means old snow, snow that is at least one year old. In Greenland pure ice is found near the coast in the marginal zone of the inland ice. That is the zone between the edge of the ice and the snow limit. Here the annual ablation (*i.e.* melting plus evaporation plus the effect of snowdrift) outgrows the annual precipitation. The marginal zone is about 25 km. wide in the place of our ascent to the Ice Cap. Here conditions for measuring the thickness of the ice are quite the same as in the Alps. This was proved by the fact that the waves have the same speed as in the alpine glaciers. Farther to the interior begin the accumulations of snow, the firn region.

Let me give an outline of the physical conditions of firn. In Eismitte we had a good opportunity to investigate the firn in a shaft down to a depth of 16 m. The firn consists of grains which grow gradually by sublimation. Evaporation

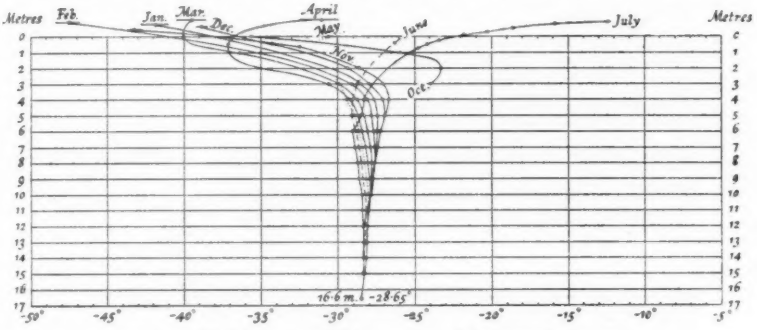


Fig. 3. Eismitte : monthly means of firn temperatures

is going on on the surface of the small grains. The moisture produced by this evaporation settles down on the bigger grains and makes them grow, but exceedingly slowly because temperatures are very low. At a depth of 16 m. the temperature was always about −30° C. (−22° F.), the diameter of the grains was about 1 millimetre.

It is not difficult to distinguish layers of snow. There are many layers caused by the precipitation of the snowstorms. But it is impossible to see the stratification caused by the change of summer and winter, as we can in the alpine glaciers. During the whole winter I measured the specific gravity of the firn from the surface down to a depth of 15 m. The result of 120 measurements was successful; the change of summer and winter layers was ascertained by the changing densities. On the whole the density increases, but with small oscillations, so that each winter layer is a little denser than the adjoining summer layers. That is the reverse of the conditions in the Alps. Thus the annual accumulation could be measured. During the last twenty years the annual accumulation of the inland ice in station Eismitte amounts to 1 metre of snow or 31 cm. of water. That is of course not quite the same as the annual precipi-

tation in the strict meteorological sense, because the increase of the snow is the effect of the meteorological precipitation, the evaporation, and the snow drift.

Several times we heard and felt a kind of earthquake: on 2 October 1930 at 01.20 a.m.; on 19 February 1931 at 06.30 p.m.; on 2 April 1931 at 06.55 a.m. (Middle Greenland Time). We called it *Firnstoss* (Firnpush or Firncrash). It consisted of a noise approaching rapidly; then followed a loud crash; and then the noise ran away. Our mercury barometer, which had been hung in a separate ice cave at a depth of 6 to 8 feet, was caught and got nearly broken.

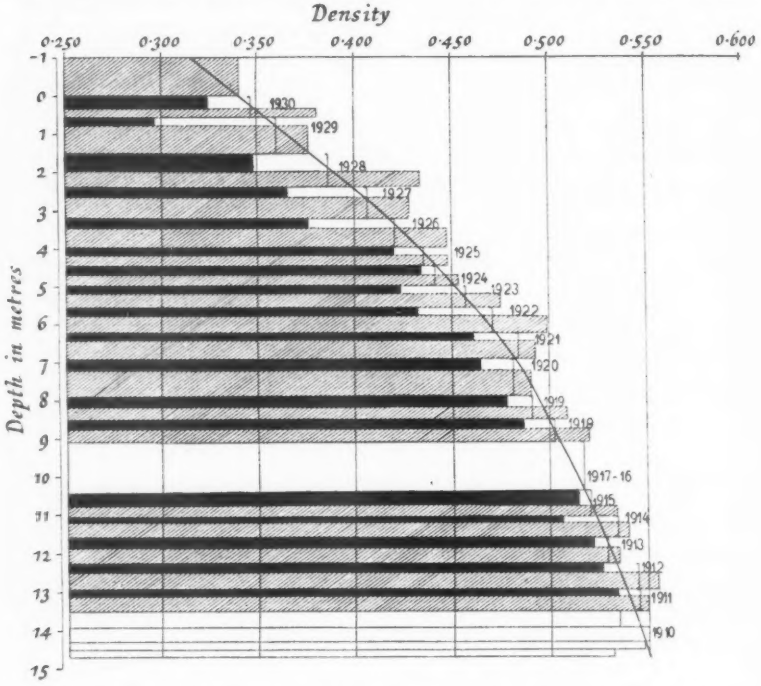


Fig. 4. Eismitte: firn-densities and depths

The layers were compressed by 1 inch. Later on we found in the shaft some soft layers of snow as far as a depth of 22 feet. But below the firn was quite hard like wood, without soft layers. It seems to me that the soft layers can finally not carry the increasing weight of the topmost layers and are suddenly compressed.

In Eismitte I built an apparatus (Fig. 5) with the object of measuring the speed of the compression of the firn layers. It consisted of boards taken from our food boxes. We called it "firn-shrinking-recorder." It is placed in a niche of the shaft wall. The top and bottom boards are walled in the firn by means of

a mixture of snow and water forming a very good and hard mortar. By the shrinking of the firn these two boards approach each other and this movement is transferred by the horizontal lever and a pen on a piece of paper on a ten-times enlarged scale. Five such apparatuses were fixed at different depths of the shaft and our so-called baggage room.

The establishment of the annual accumulation of snow is as follows: Let us take four adjoining layers (*i.e.* the accumulation of four years), for instance the four layers 9, 10, 11, 12 with the densities $d_9, d_{10}, d_{11}, d_{12}$. After the lapse of one year our group of layers has sunk deeper by one annual layer, and is then in the place which a year ago the layers 10, 11, 12, 13 occupied. The result is the same as if the layers 10, 11, 12 had suffered no change at all, whereas the layer 9 has turned into layer 13. The density of a layer is inversely proportional to its thickness. Therefore if the thickness of layer 9 is equal to t, the thickness of the more compressed layer 13 is $t \,.\, d_9/d_{13}$ and the shrinking of layer 9 is $t - t \,.\, d_9/d_{13}$. This is the recorded shrinking of the layers 9, 10, 11, 12 in the course of one year. I will call it r. Thus I get the equation:

$$r = t - t \,.\, d_9/d_{13}$$
$$= t(1 - d_9/d_{13})$$
$$\text{and } t = r \,.\, d_{13}/(d_{13} - d_9)$$

The results of these measurements furnished another method of finding out the annual accumulation of snow and were in close correspondence with the measurements of the summer and winter layers.

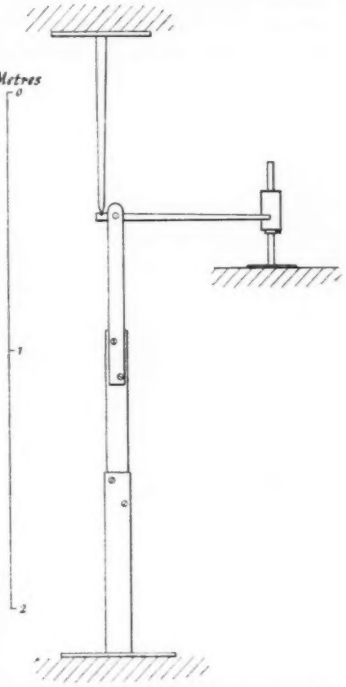


Fig. 5. Indicator for firn-compression

The physical conditions of the firn at greater depths are not yet investigated. It must be supposed that the temperature and the rise of the granules increase, and that the ice at the bottom melts, owing to the warmth of the earth.

Let us return to the ice measurements. Here is a summary of the speed of the longitudinal waves in pure ice and firn:

Time	*Place*	*Speed*	*Distance between explosion and seismograph*
1926–29	Alps	3400–3600 m./sec.	0–1800 m.
1929	Kamarujuk and Kangerdluarsuak glaciers	3400–3700 m./sec.	0–1050
1929	Inland ice 42 km. from the margin	1570 m./sec.	50
		2260	105
		3180	1053
		3470	1450–1858

The measures of 1931 give a similar result.

The direct longitudinal waves travel near the surface, but the deeper, the longer the path from the place of the explosion to the seismograph. The speed of the waves in an elastic medium is the greater the more elastic the medium is, and the smaller the heavier (specifically) the medium is. In the topmost layers of the firn the speed of the waves increases with the depth, but it is uncertain whether the speed increases continuously to the bottom of the inland ice or not. The increasing temperature of the ice and the various sizes of air bubbles exercise an influence on the speed and on the path of the waves (according to Snellius's Law of Refraction). As we know little about the conditions of the inland ice in great depths, it is not always possible to distinguish

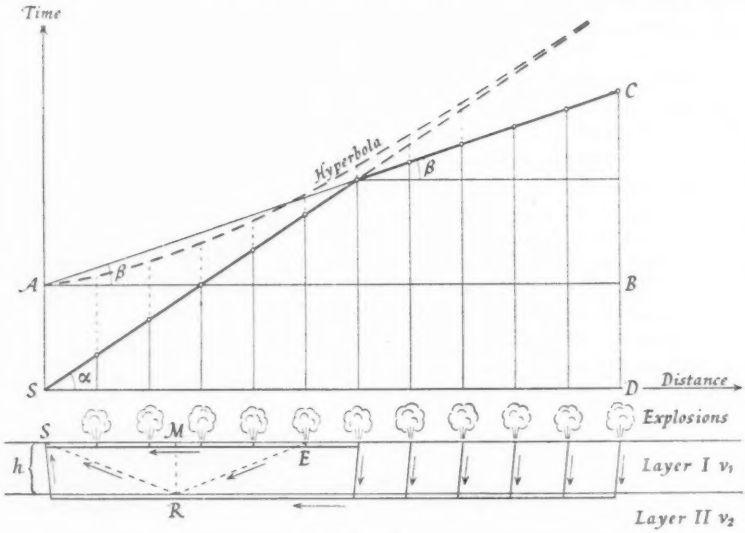


Fig. 6

whether a reflected wave comes from a layer in the inland ice or from the bottom itself.

To give an impression of these conditions I am going to consider a relatively simple case. I suppose we have two layers with different speeds of the waves v_1 and v_2, the upper having the smaller velocity. We bring about several explosions at increasing distances. The times of the direct longitudinal waves increase proportionally to the distance (see Fig. 6). But if the distance is great enough the waves running through layer II will be the first at the seismograph. If I choose a still greater distance, the time will increase slower than at the first explosions on account of the greater speed in the underlayer, but still proportional to the increase of the distance. The line bends and is then straight again. I extend this last straight part of the line as far as the time axis. In regarding the graph we have the following equations:

$$\text{Layer I, } v_1 = \cot \alpha\text{; layer II, } v_2 = \cot \beta$$

The time and the path of the waves last mentioned consists of three parts: (1) The waves penetrate layer I nearly vertically; (2) the waves travel in layer II; (3) the waves plunge up nearly vertically. We can see these three times at the graph. The whole time is:

CB is the time of the waves in layer II.
BD=AS is the time for going down and up through layer I.

As we know the speed of the waves in layer I and the time, we can work out the thickness of layer I. It is $h=\frac{1}{2}\mathrm{AS} \cdot v_1$.

Now for the reflected waves from the surface of discontinuity. According to the drawing on p. 342 we have the equation:

$$\mathrm{MR}^2=\mathrm{ER}^2-\mathrm{EM}^2$$
$$h^2=\mathrm{ER}^2-(\tfrac{1}{2}d)^2$$

The corresponding equation is also right for the corresponding times. If the thickness h is constant and the distance d changing, the graph of this equation is a hyperbola. In the case $d=0$ we have $2\mathrm{ER}=\mathrm{ERS}=2h$, *i.e.* considering the corresponding times, the hyperbola cuts the time axis in A, the same point where the extended straight line cuts the time axis. Thus the measurement of the thickness of layer I can be done twice. If the speed of the waves increases gradually, the firn must be divided into several parallel layers. Thus the path of the waves can be worked out approximately.

In 1931 Dr. Wölcken, Dr. Brockamp, and Herdemerten, members of our expedition, got reflections from the limiting border between the firn and the underlying ice. That was 62 km. away from the margin of the inland ice. In that place the firn was 300–350 m. thick, the underlying ice about 1000 m.

It is probable that the surface of the underlayer is not level. In regions formerly covered with inland ice, *i.e.* in Sweden, Norway, and so on, the surface is not at all a peneplain but has a considerable relief with deep valleys and high mountains.

I give an example of these conditions as it is important for geographers to get an idea of the difficulties of these measures.

I suppose that the speed is constant at all depths. That can be read from the time-distance-line as described before. We bring about several explosions in order to get reflected waves. If the bottom is not level, the points of the reflected waves in the graph do not lie on a hyperbola. The length of the path of the reflected waves is known from the record. It consists of the two parts r_1 and r_2. As the point of reflection is not known, it is not known what part of the path is the shorter or the longer; but the sum r_1+r_2 is known. For this reason the point of the reflection lies at any rate on an ellipse with foci E and S. The horizontal axis of this ellipse is the length of the path of the reflected waves. We bring about several explosions at different places and put up the seismograph at varying places. We draw all these ellipses. All these curves envelop the form of the bottom. In this way it is possible to get out the form of the underlayer approximately.

120 km. away from the margin of the inland-ice my colleagues took so many measurements of the thickness that it was possible to investigate the form of the bottom by combining several measurements. In this place the inland

ice was 1600–1800 m. thick, and the bottom had inclinations up to 30°. In Eismitte we had not so much explosive, so that the seismograph was put up only in one place. We got only a few reflections. Therefore it was impossible to find out the form of the bottom. According to the preliminary results the thickness of the ice in Eismitte amounts to about 2000 m., but there is a possibility of its being anything between 1800 and 2700 m. We must always bear in mind the difficulties mentioned above, especially the possibility that we have reflections from a surface of discontinuity and not from the bottom of the Ice Cap.

When we had made our first measures in Greenland in 1929 we believed we had mastered the main difficulties. But now we know that we are at the beginning of new problems. We need economical methods to undertake as many measurements as are required for getting out the form of the bottom in detail. It seems to me that for a long time to come this will be the experience of all Greenland expeditions: results that have been attained will be the source of new problems.

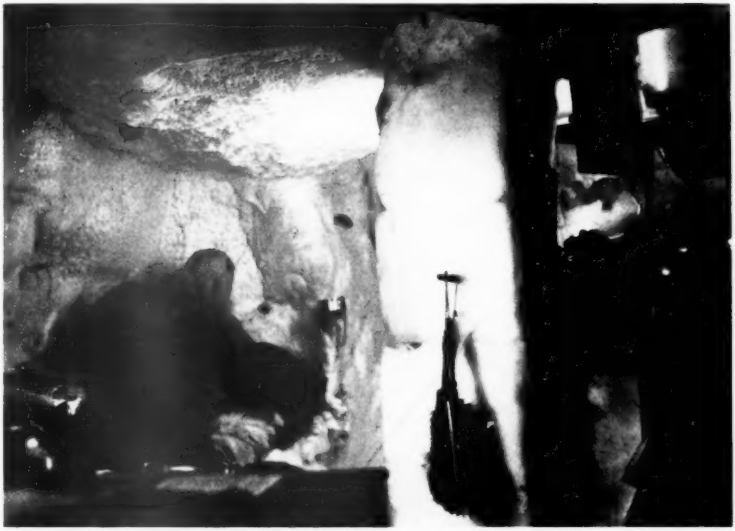
GREENLAND AS A SWITCH FOR CYCLONES

DR. J. GEORGI

AT the last meeting of the British Association I had to show that Greenland represents an uninterrupted wall for a length of 2200 km. in meridional direction higher than 2000 metres. Air masses east and west of Greenland may have a much different density and thermometrical gradient; they cannot mix together in the usual way, because the lower strata, 2–3 km. thick, *i.e.* the most active air masses and one-fourth of the whole weight of the air-column, are divided from one another.

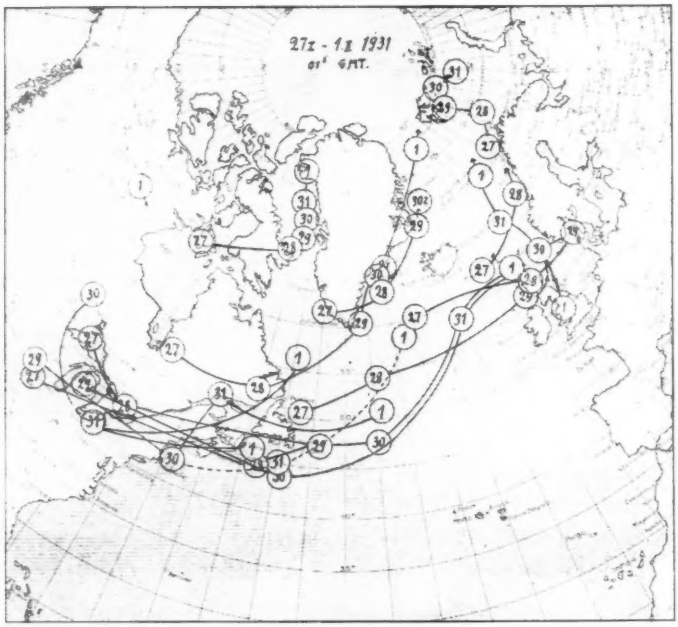
Since that time I have become acquainted with the excellent paper of Mr. S. T. A. Mirrlees in the *Geographical Journal:* "The Weather on a Greenland Air Route." In that paper the examples of weather on Mr. Watkins's base and Ice Cap station were most surprising. It seems that every strong wind at this Ice Cap station causes first strong southerly wind, and afterwards in the rear of the depression north or north-west gales. But this northerly gale is missing absolutely at A. Wegener's station Eismitte. It is hardly to be expected that two stations at a distance of only 440 km. should differ in such a striking and fundamental manner. Mr. W. H. Hobbs is right in saying that Eismitte lies probably not at the highest point, but on the western slope of the inland ice. But the slope in this region is so small that only sensitive instruments can measure it. Also the position of Eismitte, 500 metres higher than the English station, is not so important, because between Iceland and Greenland I have measured the northern storms up to 10,000 metres high.

Mr. Mirrlees has published the meteorological data for two storm-periods (27–31 January and 16–20 February 1931) for the Base and the Ice Cap station of the B.A.A.R.E. According to that we find a great similarity of the two inland-ice stations in relation to the southerly winds. When one of these

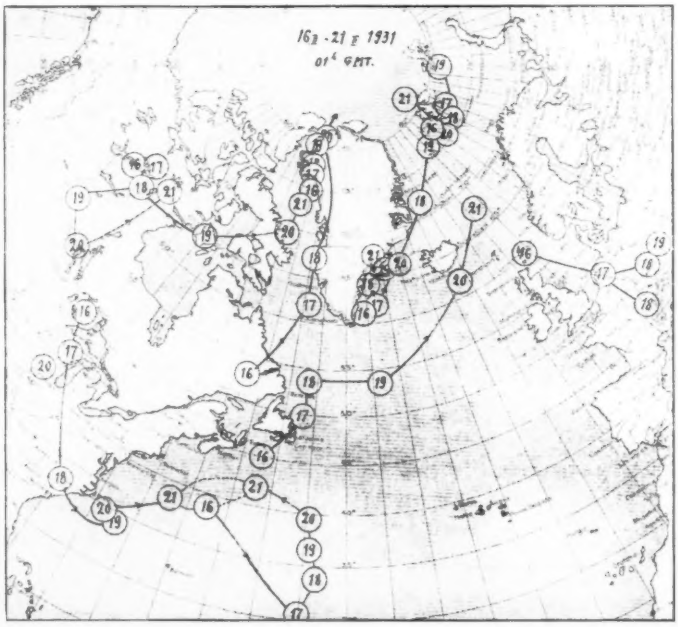


Interior of Eismitte; pillar of firn built to support the sagging roof

Dr. Sorge in the firn cavern during the winter at Eismitte



Tracks of Depressions 27 January to 1 February 1931



Tracks of Depressions 16 February to 21 February 1931

stations has a south-easterly or south-westerly gale, the same weather prevails also at the other station. Quite different are the conditions in the second period of the low. Then the English station shows typical rear-weather with north-western or northern gale. But at the German station at the same time light winds blow from various directions.

It may be that this difference expresses itself in the relief and in the form of the snow-surface. When coming to the middle part of Greenland in the summer of 1930, we found sastrugi only from south-east and south. We counted on this fact in digging our ice-cave. It is a strange idea that a few hundred kilometres south the entrance of this cave would have been filled up with snow, and we should have suffered the same fate as Mr. Courtauld, to be deprived of access to the surface. Near to the English station the frequency of northern winds can be also determined in the form of surface.

With the disposable material, *i.e.* the paper of Mr. Mirrlees, observations placed at my disposal by the courtesy of Mr. W. H. Hobbs, and by the Danish Meteorological Institute, I have completed the weather-maps of the Deutsche Seewarte for the two weather-periods mentioned above. One will see in the two figures the tracks of depressions. The centre of every low is signified by the date. It is seen that the tracks have apparently been modified by the existence of the Greenland continent. It is evident that the western slope is mostly influenced by the few but stationary lows of the Davis Strait, whose normal eastward movement is stopped there. On the other side the region near the English station is influenced to a higher degree by the lows between South-east Greenland and Iceland, and these lows cause the northern storms mentioned above in their rear. But on account of the direction of the east coast the track of these depressions is deflected to the north-east, so that at latitude 71° N., in the middle part of the inland ice, they are no more perceptible. There, near the German station, the warm air masses of the Davis Strait depressions dominate.

From our knowledge of other regions we must suppose that the zone where these warm and wet air masses interfere with the stormy and perhaps colder rear of the East Greenland lows is extremely unsettled and abundant in precipitation. This region, between Eismitte and Angmagssalik, may be unfavourable for air navigation. It seems that the circulation on the western slope of the inland ice is the more lively and the temperature there the higher the farther to the south the origin of these cyclones lies.

An interesting conclusion arises from the paper of Mr. Mirrlees. On considering the barometrical change in connection with the direction of the wind one may find that the wind on the inland ice changes—*e.g.* at the English station turns from southerly to northerly gale, at the German station from southerly gale to light breeze—when the air pressure is the same in the Disko Bay and near Angmagssalik. This relation is established in the two periods communicated by Mr. Mirrlees, and I dare not venture to generalize this small observation. But should this conjecture be confirmed later on we should gain apparently a good expedient for meteorological forecasts over Greenland for the use of aircraft. I have mentioned this conjecture also as a specimen of the advantages that arise, when the meteorologists of two expeditions work together.

DISCUSSION

Before the papers the PRESIDENT (Admiral Sir WILLIAM GOODENOUGH) said: The death of Alfred Wegener deprived the world of a great scientist. He combined in a rare way many sciences—botany, geology, all those matters which occupy those who may be termed the students of the Earth. He added to it great courage, both moral and physical. He held certain ideas which we all know were not accepted by others equally studious. Some thought them to be extreme. With it all he held those opinions and ideas with a clarity of vision and courage which was very remarkable. His physical courage was equal to his moral courage, for it was, in all probability, his physical courage which ultimately caused his death. Though his death was a great loss to science, what he, were he still alive, and what all his friends would wish us to remember, is not the loss his death occasioned, but the great gain that his life gave to science. I have on more than one occasion spoken of him from this platform, and I hope, sir, that when you return to your country you will tell your countrymen, and more especially your fellow-scientists, how greatly we respect the memory of Alfred Wegener.

Mr. Sorge, who speaks to us this afternoon, has made himself a specialist in the seismic methods of sounding glaciers and icefields. First on the Swiss glaciers; then he spent two seasons with Alfred Wegener in Greenland, and he was in the winter of 1930–31—that winter which we in this country remember so well from the activities of others farther south—on the Central Ice Station. He will speak to us to-night on the scientific results of that expedition. We shall be indebted to him if he gives us his opinion on the value of the explosion method and the possibilities of developing it by increased sensitivity of instruments or perhaps by some other method of producing waves other than by explosion. Dr. Sorge, it is not our custom to make long introductions of lecturers, especially in the afternoon, and I invite you to deliver a lecture to which we look forward with very great interest.

Dr. Sorge then read the papers printed above, and a discussion followed.

The CHAIRMAN (Mr. J. M. WORDIE): The President, unfortunately, has been unable to remain until the end of Dr. Sorge's paper. I feel sure he would have been the first to appreciate the interest of the remarks and the extraordinary number of problems which Dr. Sorge managed to introduce into his lecture. He dealt in some detail with the method of ice-sounding. We are glad that he emphasized that, and I am sure it will give rise to a good deal of discussion. I call upon Professor Rankine.

Professor A. O. RANKINE: I would like to take this opportunity of thanking the Society for thinking of inviting me to come to hear Dr. Sorge's paper. The particular application of seismic work in which I have been interested is not the problem of measuring thickness of ice, but the more economic problem of using seismic methods to discover the underground structure of the Earth, more particularly in relation to the search for oil. Oil occurs in the world usually in association with underground bodies like large domes of a rock salt or large masses of limestone in anticlinal form, both of which have different elastic properties from the rocks which lie above them. Consequently, a like method to that which Dr. Sorge has described has been used, in some cases with success, for the purpose of discovering how deep a limestone or salt deposit is, with a view to ascertaining how far it is necessary to drill in order to find the oil.

The method with which I have been associated is the one to which Dr. Sorge referred at the end of his lecture. My own experience of examining seismograph records and trying to discover reflection effects such as Dr. Sorge described earlier, has been, quite frankly, rather unsuccessful My difficulty about the

reflection method is that the reflected wave from the interface between the ice and underlying rock mass arrives *later* than the wave which has come along near the surface, and the records which I have seen, in the majority of cases at any rate, have shown much larger indications corresponding to the direct disturbances than for the reflected disturbances. In fact, I have never seen until to-day seismograms which reveal, apparently so clearly, the arrival of the reflected disturbance *after* the arrival of the direct disturbance. The great advantage of the alternative method, which Dr. Sorge rather suggested he would have employed more fully if he had had at his disposal more explosives, is that it gives the possibility of the wave which has been down into the underlying rock reaching the seismograph before this has been violently disturbed by the wave coming along the surface. It reaches a seismograph which is quiescent and is therefore able to record quite a small disturbance. This method has been used extensively and successfully for finding depths, in cases where the overlying rock differs substantially in elastic properties from that below. I should like to ask Dr. Sorge what amount of explosive he used.

Dr. SORGE: We had upon the glaciers 2 or 3 kilogrammes of explosives. We had ammonal and gelignite from Nobel's in Stockholm, or otherwise tri-nitro-toluene, or T.N.T. as in English. And then a mixture of petroleum and potassium chlorate. That mixture is very good and is not dangerous during transit. It was mixed in the hole which we dug through the ice and snow. In the *firn* region in the interior of Greenland we had much greater quantities, several times more than 20 kilogrammes. In one case we used as much as 73 kilogrammes. In Eismitte we had 195 kilogrammes of explosives in all for twenty-eight explosions. It was impossible to take more to the interior by means of propelled or dog-sledges.

Professor RANKINE: The explosions with which I have been associated in Persia have been much larger than that, sometimes as much as a ton of gelignite being necessary in order to get records at the large distances required, some 10 or 12 miles. But it is quite clear from what we have heard of expeditions to Greenland that it would be impracticable to transport such large quantities, and it seems to me therefore that it would be wiser to multiply, not the number of explosions, but the number of seismographs, so that one explosion would serve to give at the same time quite a number of records.

I think the expedition, and Dr. Sorge particularly, are to be congratulated on having obtained such positive results out of so few actual possible observations; more particularly are they to be congratulated on the convincing proof of the efficacy of the reflection method when properly interpreted.

There is another point which has to be borne in mind in connection with the proper observation of reflecting effects. Do we really know what the explosion is like? Do we know what actual movement of the ice surface is brought about by the explosion? I have always been rather hesitant about selecting one of the humps on a seismogram and saying, "That is reflection." How do I know it is not just a continuation of the original explosion? And how can I, in practice, distinguish it? No doubt Dr. Sorge's great experience helps him to do so, but without a great deal of practice in reading seismograms one might be led into error. It is for this reason that hitherto I have preferred the so-called refraction or diffraction method to which I made reference earlier.

Professor DEBENHAM: I am very glad that Dr. Sorge chose for special emphasis in his talk the question of the sounding of the ice. I do not know whether I am speaking for most glaciologists, but I think it is true to say that it was a tremendous surprise when we first heard that the Wegener Expedition results for thickness of the Ice Cap were of the order of thousands of feet where, I think, many suspected

only hundreds of feet. We had no very good reasons, it is true, for suspecting that the Ice Cap would be only 2000 or 3000 feet thick, nothing better than measuring the profiles of outlet glaciers from the Antarctic for instance, and that kind of estimate. Yet I think it was a great surprise to most who had studied ice-caps to find there was a thickness of as much as 8000 feet or more in the centre of the Ice Cap. That is why I think I am right in saying that this is, in many ways, the most momentous piece of work of a scientific kind connected with ice that has happened for a very long time, because, as Professor Rankine said, though it is of academic interest only, it has such wide repercussions. If, for instance, the height of the Ice Cap in the centre of Greenland is nearly 10,000 feet, while the height of the land underneath is only 1000 feet above sea-level, it will at once lead to a large number of other questions with regard to the elasticity of the Earth's crust; as to what may have happened in the Pleistocene Ice Age, for instance, when we had presumably the same kind of ice-cap in Great Britain; in fact, there is no end to the echoes of these explosions of Dr. Sorge's.

I was interested to hear Dr. Sorge recommend the electro-magnetic method of receiving a shock as against the mechanical method which the German Expedition used. The electro-magnetic method should be more sensitive. We are sorry, some of us in this Hall, that we have no records of that type to show Dr. Sorge. An instrument was taken to Iceland by the Cambridge University Expedition last summer, but it broke down through some quite minor fault, minor in the sense that it was nothing to do with the echo-receiving mechanism, and no records were obtained.

I must not take up too much time, but there is one question I would like Dr. Sorge to reply to, and that is to tell us, if he can, what sort of accuracy he gives to his figures: whether he considers them fairly accurate or whether he may be as much as 1000 feet out. Professor Rankine said he was sometimes doubtful as to which wave is being recorded. If these are large systematic errors it may be that the estimates of former glaciologists may not have been so far out. It certainly is somewhat difficult to believe that there can be 8000 feet of ice at the centre of the Ice Cap. I would like Dr. Sorge to tell us whether he considers his figures fairly accurate.

Dr. SORGE: At a distance of 120 kilometres from the ice margin my friends took a great number of measurements, and it was possible to work out the profile of the *firn*, or the underlayer, and there they found that the bottom had inclinations up to 30° at that place, and they did not find the deepest and the highest points of the underlayer. The thickness of the ice at that point was between 1600 and 2000 metres.

Now in Eismitte we made twenty-eight explosions and we had only two registrations of reflected waves, and those two reflected waves give a thickness of about 2000 metres—about 6000 feet. But it is not certain whether these waves are reflected from the surface of discontinuity or from the bottom itself; and moreover we have on the registrations waves which are not quite distinct. It is just possible that they are reflections of the bottom itself. If these reflections are indeed real reflections of the bottom, then we should have a depth of 2700 metres. It is very difficult to give now a definite answer, but I hope later on that it will be possible to give a better result. It is quite certain that the depth of the inland ice is about 2000 metres at least, probably much greater—about 2700 metres. However it is impossible to say whether the point of the reflection can be placed in the middle between the seismograph and the point of the explosion. That is a great pity, because we know nothing about the surface of the underlayer. It may be the same as in Norway, and so on, and in other countries which were under a thick layer of ice in the Ice Age; that it is not all a flat country, that there are high

mountains and deep valleys, and it may be that in the surroundings of Eismitte the depth is 1000 metres greater or less than at the station itself. It is not very far from the margin, and at a distance of about 60 kilometres from the margin my friends found a difference in the depths of 900 metres, and they found the ice fjords very extended into the interior of Greenland. So we must suppose that Greenland is indeed a mountainous country below a thick layer of ice. It is nearly certain that there are thicknesses of much more than 2000 metres, but also mountains which may rise to considerable heights. Now the later discoveries of the Watkins Expedition, the very high ranges, some 100 kilometres from the east coast, may prove that there is a very high mountain near the range on the east coast, also below the ice, and that on account of that the ice flows to the west. I am sorry I cannot give at this stage the exact results.

The CHAIRMAN: Is there present a representative of the Scientific Research Department of the Admiralty who would like to take part in the discussion, or a representative of the Science Museum?

Mr. LANCASTER-JONES (Science Museum): I think perhaps the question of the accuracy of the reflection shooting which was used on this expedition rests rather, very importantly, upon the speed of propagation in the ice. The velocity—I think Dr. Sorge gave somewhere of the order of 3500 metres per second—is very high compared with that in many rocks. What is the speed in the rock below the ice?

Dr. SORGE: The speed is 5000 to 6000 metres. That can be measured by the angle of total reflection. We have measured it upon glaciers. If the speed in the ice is 3500 metres a second and in the rock 5000, then the angle of total reflection is nearly 45°, because the quotient is nearly 0·7, which is the sine of 45°. Therefore if the distance between the point of explosion and the seismograph is twice as great as the depth, we have a right-angle triangle, and the reflected waves become suddenly very high, the amplitude is very great, and 5000 metres at least is the speed.

Mr. LANCASTER-JONES: I thought that would yield some very interesting information about the nature of the rocks below the ice, but unfortunately it seems to bring into a little more prominence the particular objection Professor Rankine raised with regard to interference in other ways. I do know that for the last two or three years in the oilfields in America they have had to fall back on reflection shooting as distinct from refraction; that is using the method that Dr. Sorge used of reflection shooting, on account of the very deep petroleum deposits that they are now trying to locate. Practically all the shallow deposits have been located. Now they are after some 5000 or 6000 feet below the surface, they find reflection shooting is the most practical method. So that it is just possible that because of the very great depth that Dr. Sorge was dealing with—the order of 2000 to 3000 metres—reflection shooting does operate more suitably and gives perhaps time for the reflected wave to make itself evident compared with the actual direct wave through the top of the ice.

I must say I was very much impressed by the actual seismographs and the clearness with which that wave was shown up. Normally, in geophysical work for oil and so on you get an earlier wave very much more quickly and the wave you are after comes rather more quickly on top. The difficulty is to separate the waves, as Professor Rankine has said. But I think in the cases shown there was distinct separation. The error is probably not more than 5 per cent.; with a wave so clearly shown I think the accuracy of this measurement of depth must be taken as quite reasonable, so that the error in the estimate of a few thousand metres is, I think, within 100 or 200 metres.

The CHAIRMAN: Professor Debenham has referred to the instrument taken to

Iceland by the Cambridge University Expedition. Mr. Roberts is present. I wonder if he would like to speak.

Mr. BRIAN ROBERTS: I have listened to Dr. Sorge's paper with the very greatest interest, particularly with regard to what he said in connection with the seismic sounding of the Ice Cap. Mr. Lewis, who was the official seismologist of our expedition to Iceland is, unfortunately, unable to be here this afternoon, and I cannot hope myself to enter into the scientific discussion. The Cambridge Expedition to Iceland this year was trying, on a considerably smaller scale than the German Expedition, to find out the thickness of the largest ice-cap in the island. As Professor Debenham has said, this part of our work was a failure owing to a mechanical breakdown of the instrument before we got on to the actual sounding experiments. However we did find that it would be impossible to carry out reasonably successful seismic soundings of Vatnajökull in June or July when there is a covering of alternate bands of snow and ice some 30 feet thick. This would necessitate the use of enormous explosions. In August this had all thawed away and a surface of bare ice was left which would have been quite suitable. There is one question I would like to ask Dr. Sorge, and that is to inquire what is the minimum thickness of ice for which a satisfactory result might be expected. Presumably this depends on the capacity of the instrument used to record waves arriving in quick succession, but I should like to know what degree of accuracy could be relied on with a modern instrument?

Dr. SORGE: The smaller the better. There is not a minimum of thickness of ice. If the thickness is not great the measurements are easy; but there too some grammes of explosive are required. On the *firn* you have the greatest speed. We can read the film of the *firn* to 1000 of a second, and then can work out the record of the speed. For instance, if we have exactly one-hundredth of a second the wave through the ice is between 3500 metres. The smallest glaciers have thicknesses of some hundreds of metres. A thickness of 130 or 150 metres is quite sufficient for ordinary measurements. The smallest ice domes have thicknesses which are sufficient for ordinary measurements.

Mr. HINKS: You can separate the two waves in very thin ice?

Dr. SORGE: Yes, if you take a considerable distance between the points of the dome and the seismograph it is always possible to distinguish the waves. It is however most important to have a good damping for the seismograph. The waves must be damped very quickly. In Eismitte the damping was not very satisfactory. The amplitudes decreased very slightly, and so we had not such clear seismograms at Eismitte as I showed on the screen. Therefore it is a little difficult to distinguish all the waves. The first wave had not ceased when the next began.

The CHAIRMAN: Mr. Courtauld is here. Would he like to compare his earthquakes with those which Dr. Sorge has spoken of?

Mr. AUGUSTIN COURTAULD: The paper we have just heard is, I think, especially interesting because the observations Dr. Sorge has described are entirely new to exploration. It sounds fantastic to hear that the depth of 9000 feet of ice can be sounded by the echo from a trivial explosion of a few pounds of dynamite on the surface. Few people can realize what difficulties these men had to work under. They had neither house nor tent, very little fuel, and a bare sufficiency of food; yet they were not content with eking out their existence, but, as we have seen, they made every conceivable sort of observation under conditions which one would have thought would have entirely prohibited any sort of scientific work.

Dr. Sorge's mention of the noise phenomenon greatly interested me. On two occasions I had the same experience: it sounded like an express train coming

at a great speed, ending with a tremendous crash like an avalanche on the top of the house. However there was no change in the surroundings of the house so that it could not have been a fall of snow from above or subsidence from below. The only explanations I could think of at the time were that it was either an earthquake or a collapse of the under side of the ice-cap where some great cavern might have formed. However I am told that both these theories are probably wrong.

Mr. S. T. A. MIRRLEES: I was very interested in the meteorological part of Dr. Sorge's paper in which he brought out the remarkable difference in the conditions at the two ice-cap stations established by the British and German expeditions. If we assume that this slide is correct in so far as it shows the British and German stations on opposite slopes of some sort of ridge, then we have the fact that the prevailing winds at the German station were south-east, and at the British station north-west; that is to say, in each case the prevailing winds were down-slope, which is exactly what you would expect, because the cold air tended to run downhill; but there is an important difference, because at the British station uphill winds were at times strong, whereas, apparently, at the German station the uphill winds hardly had any strength at all. At the British station some of the strongest winds were in the uphill direction. There is another difference between the two stations which might be mentioned. According to some details which I have seen published, the maximum of temperature at the German station was caused by strong winds, whereas at the British station the temperatures associated with strong winds varied from $+20°$ to $-40°$. These facts suggest some important difference in meteorological régime between the two stations, and are the more surprising in view of the small difference in latitude which separates the two stations.

One is tempted to start making theories, but, as Dr. Sorge stated, the time is not yet. Dr. Sorge's main thesis seems to be that the wedge-shaped mass of Greenland acts as a barrier around one side or the other of which the majority of the depressions travel, but one slide shows a depression track crossing southern Greenland. I think the data give fairly good ground for saying that, on occasion, considerable masses of air can be forced right up from sea-level across the ice-dome in the latitude of the British station, not only from the westward direction but from the eastward. At the German station, apparently, this does not hold.

Another point that Dr. Sorge mentioned was that of forecasting for aviation. There is one question I should like to discuss with him, the use of isobars of pressure at sea-level. The isobars over Greenland on the chart shown were drawn without reference to the conditions on the Ice Cap. The interesting thing to me was that I found by using this chart of something which did not exist, it would have been possible to forecast, to the aviator who was about to take off for his flight, with a very fair degree of approximation, both the wind and temperature at the Ice Cap station of the British Expedition.

In view of the remarkable differences in conditions which appear to have existed at the two stations, I think Dr. Sorge's concluding remarks, in which he implied that the full results of the two expeditions cannot be obtained unless the meteorologists compare notes, are very much to be commended.

Mr. HINKS: The hour is very late, and I must say only this, that during the last two or three days, in preparation for understanding Dr. Sorge's paper, I have been reading a chapter in Dr. Harold Jeffreys's book, 'The Earth,' the chapter on Seismology which discusses the reflected wave problem of seismologists. I commend that chapter to any future expedition and to any one who wishes to understand the analogous problems in this work of Dr. Sorge.

As to the actual work itself, it has been borne in upon me very much that the

weight of explosives must be a very important matter. I hope that ingenious people will give their minds to improving the methods of making the explosion, or the equivalent of it, just as they have in developing echo-sounding under the sea. They of course have not in the ice a nice homogeneous medium like that under a ship, so that one can by super-sonic methods get the vibration and do all one wants. But it does seem to me evident that we must give our ingenuity to finding some method of improving the sending of shocks through the ice, and not have to lug about such great quantities of explosives.

The CHAIRMAN: Dr. Sorge, I think I should thank you on behalf of everybody present for your most interesting lecture and for the stimulating discussion it has evoked. I hope you derive as much benefit from the discussion as we have from your lecture. I do not think I have previously listened to such an interesting paper here. You have coped with the difficulty of giving it in a most admirable fashion. Those who go to the Antarctic always wonder what the conditions are below the ice, and the same in Greenland. We hope you will be able to do more and perhaps carry out Dr. Wegener's wishes in greater detail on future occasions.

THE CULTURAL LANDSCAPE

MAN'S ADAPTATION OF NATURE: Studies of the Cultural Landscape. By P. W. BRYAN. *London: University of London Press* 1933. 9×6 *inches;* xviii+386 *pages; illustrations and maps.* 16*s*

DR. BRYAN puts this book forward not only as a serious contribution to knowledge, but as a serious contribution to thought: in brief, as a Philosophy of Geography (p. v). It has been necessary therefore to examine it with meticulous care, questioning and testing its statements and conclusions word by word and line by line; and since the final judgment must be adverse, it may be summarized without equivocation at the outset. Dr. Bryan has invented a jargon and proclaimed a philosophy. So severe a stricture must be carefully supported. It will be admitted that a serious study of the history of geographical ideas is the prerequisite of a fresh contribution to that aspect of the subject: Dr. Bryan's work shows no evidence of such a study. His faulty assumptions as to Strabo's influence are perhaps of little moment: not so his remarks concerning the teaching of Humboldt, Ritter, and Ratzel (pp. 3–7). There have been, he tells us, two main lines of geographical development: "First under the distinguished impulse of Humboldt and Ritter" ideas were worked out which "made the central feature of geography the study of one aspect of the environment [physiography], a view of geography from which up to lately we were struggling to free ourselves. . . . The second main path . . . lays the emphasis on man and his activities in relation to his natural environment, rather than on the land forms, or natural environment itself. It began with Ritter and Humboldt." Has Dr. Bryan any first-hand acquaintance with the writings of these two great pioneers, so diverse in their geographical activities and their points of view? He mentions Davis's name. Has he studied that worker's 'Content of Geography'? Has he, further, made himself familiar with Ratzel's teaching *as a whole*, before summing it up in the sentence "the fixed character and the inevitability of the control exercised in any given set of natural conditions is dogmatically asserted"? In his great *Völkerkunde* (1885–88) Ratzel wrote: "We shall therefore bestow a thorough consideration upon the external surroundings of the various races, and endeavour *pari passu* to trace the historical development of the circumstances in which we

find them to-day. The geographical conception . . . the historical consideration . . . It is only from *the combination of the two* that a just estimate can be formed." And again: "Nothing gives a more striking lesson of the way in which the utilization of Nature depends *upon the will of Man* than the likeness of conditions in which all savage races live in all parts of the earth, in all climates, in all altitudes." Is this to regard man as "the slave of circumstances"? (p. 8). If further evidence is required of Dr. Bryan's really astounding disregard of the work already done and the ideas formulated in the geographical field, it is to be found on p. 13, where after writing that "Geography . . . is not primarily a study either of the human activity complex or of the natural environmental complex, but of the adjustment of the one to the other," he adds in a footnote, "This view was first suggested by the writer in 1929." Eliminating the redundant word "complex," the present reviewer can assure Dr. Bryan that it has been the commonplace of her own lecture room for twenty years, as it was of Dr. Herbertson's since the beginning of the century. "La Terre, certes" (wrote Brunhes in 1910) "commande à l'activité humaine: mais, à son tour l'homme commande à la Terre."

Just as his central idea has long been familiar, so there is nothing new, apart from detail and nomenclature, in Dr. Bryan's use of the "cultural landscape" as the concrete mode of approach to human geography. Siegfried Passarge and Jean Brunhes, by their extensive and detailed studies, have made students familiar alike with the usefulness and the limitations of this method, and Brunhes's familiar "six types" of concrete facts of human impress on the landscape afford a far more complete and logical system of categories than Dr. Bryan's "fixed" and "movable" units. The French writer distinguishes, for example, the destructive exploitation of the soil from its constructive utilization, while Dr. Bryan is satisfied to speak of the "adaptation" of Nature, whether he means utilization, modification, destruction, or adaptation in the accepted meaning of that word. Since precision of language is of the essence of scholarly work, it is truly deplorable that any one should impose on his students as a formula for defining each feature of the cultural landscape the sentence: "It is a 'fixed'/'movable' objective expression of man's adaptation of nature in the effort to satisfy a demand for . . ." (p. 373). What if the object were a dung-heap, a shell crater, a despoiled beauty spot, or even an orchard laden with ripe and unripe fruit? This confusion of thought, and therefore of language, is apparent again and again when the attributes of the cultural landscape are detailed. It is said to have "structural form" or "anatomy" in fields, mines, houses. "It possesses movable forms *as in the cases of* men and vehicles. It has activity in . . . the movement of vehicles. Lastly it has the results of these activities in the form of . . . good government and amusement" (p. vi). And again on p. 17: "The growing crops, the moving animals . . . the playing of games, and man himself, are all parts of its physiology." In what sense a landscape can "have good government," or have a physiology divisible into "parts" which include "the playing of games" remains obscure. Dr. Bryan however seems to imply that he advances on Brunhes by listing man himself (but fortunately only while he remains out of doors) as one of the "movable units," as indeed "the major essential element," of the landscape. "Whether steadily at work in the fields and factories," he writes, "or temporarily engaged in crossing the White Pass in the Yukon gold rush of 1898, dying on the way, or among a group of Red Shirts at a revolutionary meeting at a convenient nodal point on the North-West Frontier, or having a round of golf on a sandy links with a friend, he is still an element of the cultural landscape—an element without which, sooner or later, that landscape would decay and disappear" (p. 25). In what possible sense the White Pass or the North-West Frontier, or even the "sandy links" would

decay and disappear with the disappearance of the hypothetical gentry with whom Dr. Bryan populates them must escape the casual reader. As far as the "sandy links" are concerned however the explanation is that these are transformed from a "natural" to a "cultural" landscape by the addition of the club house, greens, and the like, and that in the absence of the "movable" golfer, these "fixed units" would disappear. The reviewer has not been able to penetrate the author's meaning in respect of the pass and the frontier. Dr. Bryan however takes the surprising view that it is *only* the cultural landscape, the landscape that, as he would say, has been "adapted" by man to fulfil his desires for food, shelter, clothing, or recreation, that should be the geographer's concern. "We have," he says, "no adequate justification for discussing the physical setting before describing the facts of human use, since our principle *or criterion* in human geography is to examine the facts of the natural environment from the standpoint of human occupancy and use. . . . The fundamental point to be considered here, as in all other sciences, is the *objective, or criterion or measuring-rod*" (p. 369). All this seems very obscure, until we read beside it, from p. 13: "The geographer's approach to his subject through human activity is more fruitful than through environment, since in the former case he has ready to hand a *measuring rod* wherewith to select for study the environmental facts *which affect human activity*." (The italics are the reviewer's.)

Here we have the crux of Dr. Bryan's method, and here we have its fundamental fallacy. His "measuring rod" appears to serve him as a "divining rod." For how can the geographer select from an environment which he has not studied in full "those facts which affect human activity"? Has he an *a priori* knowledge of what those facts are? If so, whence has he obtained it, and to what purpose does he pursue a problem of which he already knows the solution? Dr. Bryan rejects as "clearly impossible" any exact study of the environment. Too careful a study of climate would make the geographer a climatologist (p. 13), while too close an attention to geomorphology would lead him "into geological descriptions and terms which may (*sic*) have little or no relationship to human activity" (p. 367). The direct consequences of such a line of argument are apparent when Dr. Bryan proceeds to make an elementary and faulty *ad hoc* classification of soils and land forms as a basis on which to "explain " the cultural landscape, and again they are seen in his use of the word "structure" as the equivalent of "geological outcrop," and even of "lithological character." This can only lead to loose thinking, the more so as the "structure" of a landscape is also defined as its fields, houses, and other "fixed units." In this connection mention must also be made of Plate 46 and the accompanying text.

It is this entire absence of a scientific method, leading the author to formulate "types" and to discuss general conclusions while failing to examine impartially the whole of the evidence, that vitiates the work (which he claims as fundamental) upon "house patterns" (Chap. VI). The making of such tracings as are here described has been, of course, for thirty years part of the routine analysis of large-scale maps imposed upon students. They provide material for useful discussion. When however we are invited to compare a "tillage pattern" and a "grassland pattern" of what is termed "house" (but is actually building) distribution, the following questions present themselves. How far has the pattern been affected by the availability and price of land, and by the incidence of road charges? How far has the speculative builder or the regional planner or the local authority been responsible for the pattern? What research has been made into the dates and the history of particular groups of buildings? Has the cartographical material, going back for at least a century, which gives the exact utilization of the fields, and location of the buildings, before the rapid change over from tillage to grass-

land, been examined in every example cited? Has the still older evidence afforded by manorial surveys been used? Have the facts as to water-table, surface water, drainage, and so on, been completely utilized? These are pertinent questions. But after all, the subject is not arising for the first time. It will suffice to quote from the penetrating critical study of Lucien Febvre, always worth re-perusal: "Let us return now to the problems of the house. To study the forms of dwellings, or the distribution of houses and villages over the whole of France. . . . The task is indeed formidable. . . . This is a question of a practical order. The value of the chapters that regional geographers write on houses lies precisely in the fact that they are 'chapters' of the whole: that their authors have acquired and show a *perfect preliminary acquaintance with the region* and its various characteristics: that they have made a long and minute analysis of the extremely different elements that may be found in the human house. But to entrust them with the task of studying the houses in all the regions of a territory like France—or even like Western Europe—is to condemn them to ignorance of any but the most obvious realities, and to make the work easy, commonplace, superficial, and paltry—a second-hand work which any man of medium intelligence could perform on the subject without special training; or else to condemn them to a detailed, profound, and personal knowledge of each region, to a full and minute study only part of which would afterwards be of any use: a task evidently absurd and impossible." The late Professor Arthur Thomson has well said that in the fact that geography is not a well-defined single science, but a combination of many sciences for a particular purpose, a fact constantly raised as an objection against it, lies precisely its virtue. It is "a unification or synthesis of complementary disciplines." Such a synthesis can however only be effected by those who have submitted to the disciplines and mastered their results. There is no short cut. "An immense perspective of toil," continues Febvre, "stretches before us, both historians and geographers, to an indefinite future. This is not the time to fall asleep in idle admiration of the poor, little, mean, and sterile system which some of our forerunners have erected. . . . There is another and a better thing to do than to linger over it—to work!" E. G. R. TAYLOR

PSEUDO-CYLINDRICAL MAP-PROJECTIONS

DIE UNECHTEN ZYLINDERPROJECTIONEN: ihre Anwendung und ihre Bedeutung für die Praxis. By Dr. KARL-HEINRICH WAGNER. (Aus dem Archiv der Deutschen Seewarte 51. Band, Nr. 4.) *Hamburg* 1932. 11×9 *inches;* 68 *pages; diagrams. M.*3

THIS work is an important contribution to the growing literature of Map Projections. It is a thesis by Dr. Karl-Heinrich Wagner, of the well-known geographical establishment of H. Wagner and Debes, of Leipzig, on a group of projections that has received but little attention, up to now, in Great Britain. The treatment is very thorough: the First Part deals with the history of this group, the early forms until the year 1890, the modern developments since that year, and a statement of the general problem; the Second Part discusses the mathematical principles and formulae; the Third Part describes the methods of drawing the various projections in the group; the Fourth Part deals with the constants; and the Fifth Part with the practical use of these projections.

In true Cylindrical Projections we imagine the network to be capable of being drawn on a cylinder. Thus, the Projection "plate carrée," or "Plattkarte," which is the simplest of all projections, consists of a series of parallel and equidistant straight lines, which represent the parallels; and, at right angles to these, a series of parallel and equidistant straight lines, at the same distances apart as the parallels, to represent the meridians; the result being a network of squares. Another very well-known cylindrical projection is the Equal-Area Cylindrical Projection, which is formed by actual geometrical projection from the sphere on to a circumscribing cylinder. And of course Mercator's is a cylindrical projection, and so is the Transverse Mercator.

Tissot, in his 'Mémoire sur la Représentation des Surfaces,' Paris, 1881, p. 132, gives the following definition: "On donne le nom de projections cylindriques à toutes celles dans lesquelles les méridiens sont représentés par des droites ayant une direction commune, et les parallèles par d'autres droites perpendiculaires aux premières." Tissot goes on to say, "Les Projections Méricylindriques se distinguent les unes des autres, et aussi des precédentes, par le tracé des méridiens de la carte, qui peuvent être des lignes quelconques." We may say then, with Dr. Wagner, that under the name Pseudo-Cylindrical Projections may be included all those projections in which the parallels are drawn as a system of parallel straight lines, whilst the meridians may be any chosen curves. One more quotation from Tissot's 'Mémoire': "Aucune projection méricylindrique n'est autogonale [orthomorphic]; il y en a, au contraire, une infinité qui sont authaliques [equal-area]."

In his historical introduction the author begins with an account of the pseudo-cylindrical projection of Apianus of 1524. In this projection the parallels are equidistant, parallel, straight lines; the distance apart, from pole to pole, is the length of the meridian. Mark off on the Equator distances equal to the spacing of the parallels. Draw a circle of which the diameter is the length of the meridian from pole to pole, the centre being the point of intersection of the principal meridian with the Equator. Extend the horizontal diameter of this circle each way, so that the whole length is the length of the Equator. Divide this equally. As described by Germain, the meridians are two different types of circles passing through these equal divisions of the Equator. For the central hemisphere, they are circles passing through the equal divisions of the Equator and the poles; outside the central hemisphere they are circles passing through these points on the Equator, the circles being of a fixed radius equal to the distance on the central

meridian from Equator to pole. Thus, the boundaries of this projection are, east and west, two semi-circles; north and south, two straight lines. We have here, for the first time, the poles represented by straight lines (*Pollinie*). The poles are, in fact, represented by the tangents to the exterior circles. In the second projection of Apianus the meridians are elliptical. The principal meridian and the Equator are divided truly and the elliptical meridians pass through the poles and the equal divisions of the parallels. This was first made use of by Arago in his 'Astronomie populaire.'

The next pseudo-cylindrical projection is of greater importance, and Dr. Wagner is able to make a correction to hitherto accepted history. This projection is the Sinusoidal, otherwise known as the Sanson or Sanson-Flamsteed projection. Germain states that this projection was devised by Sanson in 1650. But Dr. Wagner points out that the projection is already to be found in Hondius's edition of Mercator's Atlas in a map of South America, and he remarks that Mercator undoubtedly invented it, and that it should be known by the name of Mercator's Pseudo-Cylindrical Projection. This projection is too well known to require description; it is, of course, equal-area. The author also proposes that it should be called the Mercator-Sanson projection, because, though invented by Mercator, its widespread use is due to Sanson.

The next important Pseudo-Cylindrical Projection is the very well-known projection of Mollweide, which dates from 1805. In this the meridians are ellipses which meet at the pole. The Equator and the central meridian are straight lines intersecting at right angles. If the Earth's radius is 1, the semi-Equator and central meridian are each $\sqrt{2}$. In the net for the entire world the length of the Equator is $2\sqrt{2}$. The parallels are parallel straight lines whose distances apart are to be found from the stipulated condition of equivalence. The entire surface of the world is represented by an ellipse in which the east–west axis is twice the length of the north–south axis.

We are now introduced to the modern developments in the study of this group which have taken place since 1890, especially to the conception of Combined or Mixed Projections. Thus, in that year, Nell devised a projection which is a mean between Bonne's and the true equivalent conical projection; and he intimated at the conclusion of his research that the principle might be applied to the Mercator-Sanson projection, but did not carry the suggestion any farther. Ten years later E. v. Hammer formed a combined projection by taking the arithmetic mean of the meridians of the equal-area cylindrical projection and those of the Mercator-Sanson, and determined the distances of the parallels, so that the property of equivalence remained. Here, for the first time, we find a pseudo-cylindrical projection, with a "pole-line" intentionally constructed, so as to diminish the distortions.

We must pass rapidly by Eckert's projections of 1906, in which the essential feature is that the pole is not represented as a point, but by a straight line of half the length of the Equator.

And now we have arrived at the important contributions of Dr. Oswald Winkel. In the year 1921 Dr. Winkel published in *Petermanns Mitteilungen* three new projections of this type; he had already, in 1913, dealt with the representation of large areas of the Earth's surface. His first projection is the arithmetic mean between the rectangular "Plattkarte" and the Mercator-Sanson. The second is the mean between the rectangular "Plattkarte" and the Apianus projection. And the third falls somewhat outside the group of pseudo-cylindrical projections, for it is a combination of the rectangular "Plattkarte" and Aitoff's equal-area projection, and has therefore curved parallels. A description of

Aitoff's projection will be found in Mr. Hinks's book on 'Map Projections,' 2nd edn., p. 62.

The advantage of this kind of projection for world maps is that it avoids the very sharp intersections of meridians and parallels which we find, for instance, in the Mercator-Sanson projection; we can more comfortably study the sub-arctic regions, but not the polar regions themselves. It is of course possible to make the lengths along any selected parallel true to scale. (For an example of this, see *Petermanns Mitteilungen*, 1921, p. 248, where Dr. Oswald Winkel gives a plate of the combined "Schnitt-Zylinderprojektion," formed by taking the arithmetic mean between the square "Plattkarte" and the Mercator-Sanson, the lengths along the parallel of 50° in this case being made true to scale.)

Dr. Wagner devotes a few paragraphs to an account of "English" experiments in this direction; but, by a pardonable error, he includes the work of the American S. Whittemore Boggs, whose values of the N.–S. co-ordinate are the mean between those of Mercator-Sanson and Mollweide (*Geogr. J.*, March 1929); he also includes under the same heading the Interrupted Homalographic Projection of the American Goode.

Dr. Wagner mentions the valuable contribution of Lieut.-Colonel J. E. E. Craster in the *Geographical Journal* for November 1929. Colonel Craster was the first to point out that it is possible to construct equal-area world maps with hyperbolas or parabolas for the meridians, the parallels being represented by a series of parallel straight lines. He says, "The parabolic projection, which is easy to compute and draw, may perhaps be preferred to either the Sanson or the Mollweide." The attention of Dr. Wagner may be directed to the ingenious Skew Mollweide of Mr. James Fairgrieve (*Georg. J.*, March 1929), and also to the fact that the Transverse Mollweide was used by the British War Office more than twenty years ago, and that a brief account of it was given in an *Ordnance Survey Professional Paper*, No. 11, 1927.

In the mathematical section of the work Dr. Wagner first treats of the general expressions for pseudo-cylindrical projections, and remarks that the general treatment offers an abundance of possible varieties. He then discusses the networks in which the parallels are their true distances apart, including those combined projections in which the poles are represented by straight lines. Thus, to take the simplest case, for the combined Mercator-Sanson and square "Plattkarte" we find $y = \lambda \cos^2 \phi/2$, $x = \phi$.

He next deals with equal-area projections of this type, in an elaborate discussion which occupies more than twenty quarto pages, to which those interested in the mathematics of map projections may be referred.

The last section of the work treats of the suitability and importance of pseudo-cylindrical projections in practice. He draws attention to the Tilted Mollweide projection which has been issued by the American Museum of Natural History, with its centre on latitude 20° N. This is not to be confused with Fairgrieve's Skew projection.

The numerous diagrams form a useful feature of this study, which is a very thorough piece of work, deserving the attention of all who are interested in map projections. Perhaps one day we may see an English translation of it. The writer of this review is conscious of the fact that he has hardly done justice to the completeness of Dr. Wagner's examination of the many forms which may be taken by the group of Pseudo-Cylindrical Projections.

C. F. CLOSE

REVIEWS

EUROPE

THE STORY OF THE CHILTERN HEATHLANDS. By J. H. BAKER. [New, Revised and Enlarged Edition.] *Reading: Jas. Golder* (1932). $8\frac{1}{2} \times 5\frac{1}{2}$ *inches; 104 pages; illustrations and maps.* 1*s*

This motorist's, cyclist's, and pedestrian's guide to the south-west part of Oxfordshire, a region extending from Goring to Turville, and from Reading to Chalgrove, and comprising the Chilterns in their descent to the Thames Valley, is the work of a man who has known and loved this countryside for a quarter of a century and brought to bear upon it rich gifts of observation and understanding of details and much research. His subject is indeed the most out-of-the-way and unspoilt district of the Chiltern country: names like Swyncombe, Mongewell, Nettlebed, Nuffield, Ipsden, Checkenden, Peppard, and Goring Heath will suggest to the informed traveller the range and character of the region described. The writer flavours his rambles with imagination and fancy and a zest for old-time customs, and even an old-time phraseology for nature themes. His pages are generously illustrated, and conclude with a series of walks and a clear map. An excellent guide-book. S. E. W.

THE MARLBOROUGH COUNTRY: notes, geographical, historical, and descriptive on part of Sheet 112 of the One-inch Ordnance Survey Map. By H. C. BRENTNALL and C. C. CARTER. New Edition, Revised. *Oxford: University Press* 1932. $7\frac{1}{2} \times 5$ *inches; 160 pages; illustrations and maps.* 3*s* 6*d*

The authors of this book are two assistant masters at Marlborough. They are fortunate in living in the midst of a countryside which has not yet been spoiled by industrial development, and which is rich in archaeological remains. The book is an attempt to enable the boys to appreciate their surroundings with understanding. It brings class-work into touch with reality and gives an academic subject some significance for the ordinary learner. In the introduction to the new edition the authors deplore that their example has not been followed in other schools. For this they must blame the examination system, and the importance which the business community attaches to a certificate as a proof of competence. Very few schoolmasters can afford to allow the boys to stray from the academic groves to see the outer world.

The book is strictly practical. It gives concise and accurate information on all questions which could arise from the study of the map. The opening chapters describe the physical character of the district, the formation of the strata and of the river system. There is a contrast between the western and eastern areas. To the west extends the Chippenham plain watered by the Bristol Avon. Here are situated the great Wiltshire dairy farms, chiefly occupied in producing milk for London, a trade at present unaffected by the foreign competition which has caused a decline in the production of cheese. To the east lies the downland, bounded on the north by the Oxford plain and on the south by the Vale of Pewsey. This however is "merely a deep-cut notch . . . and does not finally break the continuity of the chalk, which is extended southwards to Salisbury Plain." This area is chiefly dependent on sheep-farming. Sheep, while still important for their wool and meat, are of greater importance "for their manurial and treading value in fertilizing and stiffening the soil, so much so that few hill farms can afford to do without them." The crops on the slopes are protected against March winds and stern weather by the flints in the soil, on which Cobbett heard the hammering of his horse's hoofs, as he traversed the green roads.

The subsequent chapters are mainly historical. An interesting map shows how the roads have moved since 1800. "The desertion of the down routes for the valley routes with their easier gradients is a part of our debt to Macadam." There is a chapter on place-names which is a model of method. The archaeological chapters are detailed and thorough, but the authors will not find universal assent to their assertion that lynchetts are solely of Saxon date. With the exception of the chapter on Marlborough forest, the purely historical chapters are uninteresting.

The book is well illustrated and supplied with numerous maps and diagrams. There are questions at the end of each section. The boys at Marlborough must be very clever. T. D. T.

RUMPFUNGARN. By MICHAEL HALTENBERGER. *Budapest: Gebr. Tisza* [1932]. $6\frac{1}{2} \times 4$ *inches; 112 pages; sketch-maps*

It is to be hoped that for any future edition of this useful little book the author may be persuaded to rewrite his title as 'Rumpf-Ungarn' at least, if not 'Trianon-Ungarn' (cf. 'Congress Poland'), an alternative which he himself uses. The regrettable practice of the German language which suppresses the individuality of the substantive name in such compounds leads to even less happy results in other languages: thus one of the bibliographical entries on p. 111 runs into a single word the Hungarian equivalent "Csonkamagyarország"! The expression itself, though supported by English precedent in "Rump Parliament" and now too well established to be entirely uprooted, has here the further drawback of suggesting propaganda. In this the author does himself disservice, for in reality his work is a restrained and on the whole a dispassionate synthesis of geographical data as they stand—likely on that account to win for Hungary more sympathy than is commonly stirred by special pleading. The consciousness of national loss is of course everywhere present, and in the closing chapter which deals with Hungary's position, astride the Middle Danube in the one direction and between extensions of Slavonic peoples in the other, the author ventures into somewhat dangerous speculation as to the significance of his country in *Weltpolitik*.

Apart from this however the geographer who shuns political deduction will find much valuable material concisely stated and clearly arranged under the usual headings of geology, relief, climate, and so forth. Of exceptional interest are those sections, broadly to be grouped as Human Geography, which treat of settlement, means of communication, and internal relationships generally. On the basis of the most recent figures available the need of new transport facilities to restore economic equilibrium is brought out in satisfying detail. Agriculture must now more than ever be the predominant interest, and for its fuller development some measure of decentralization seems to be necessary. Budapest, within 22 miles of the frontier, has a population which to-day exceeds one million—out of a total less than nine millions—while the next largest centres, Szeged and Debrecen, drop to the order of 100,000 only. Many of the provincial towns are indeed little more than extensive villages, serving as local markets for the surrounding settlements. Sometimes, as in the case of the curiously isolated Tanya farmsteads, they present features which merely geographical factors are inadequate to explain. In this connection the reader may be grateful to Professor Haltenberger for a historical summary which lends point to the refrain, "More was lost on Mohács field." Combined with the facts given as to present greater racial homogeneity and relatively decreased illiteracy, this retrospect will leave those who wish well to Hungary with renewed hope for the future of her intelligent and gallant people. A. J. P.

ASIA

BAGHDAD SKETCHES. By FREYA STARK. *Baghdad: The Times Press* 1932. 9×5½ *inches;* 132 *pages; illustrations* (*by* E. N. PRESCOTT)

The modest title of this book covers both its letterpress, which is a series of travel impressions in 'Iraq, and the line drawings of street and river scenes, and of such characteristic figures as a desert policeman or a Kurdish porter. But Miss Stark, who is already known to readers of this *Journal* as a traveller of courage and resource, is entirely free from the guide-book manner, and her studies of the country and people have an engaging freshness. Shrewd observation and sympathy mingle in her pages, whether she is describing her search for a house in Baghdad at a rental of eighteenpence a day, or giving a vivid account of the tiny slum dwelling, close to a mosque, where she and her maid, Marie the Armenian with her "excruciating Arabic" and uneven temper, lived for a time, until they moved to a lodging on the western bank of the Tigris, "the only sweet and fresh thoroughfare of the town: not clear water, but lion-coloured like Tiber or Arno."

Her landlord and his wife were Syriac Christians, and they invited her to share the family ceremonies, of which she gives a charming glimpse in "A Syriac Christmas" The author made many friends and acquaintances among the varied nationalities of 'Iraq. But she was not content to improve her Arabic in the city, and watch the shifting life of the river from her terrace. She made pilgrimages to Kuwait, "the little buffer state which is nothing but desert and sea"; to the temple of the Yezidis at Sheikh 'Adi; and she had the good fortune to spend two or three days in the guest tent of that most courteous host, Sheikh Ajil of the Shammar.

These sketches convey, better than far more pretentious volumes, the strange fascination of the country; its blend of antiquity and beauty with squalor, of *laisser faire* with racial pride and ambition. They show us the splendour of the wild flowers in the brief 'Iraq springtime, and also the fate which awaits Mandali, on the Persian border, once a town of gardens with the best date palms in the land; now a place of perishing trees and dwindling harvests, owing to the diversion of its water supply for agriculture on the other side of the boundary. M. K.

LA NAVIGATION DU YANG-TSEU. By WANG CHUNG-CHI. *Paris: Les Presses Modernes* 1932. 10×6½ *inches;* 316 *pages; diagrams and sketch-maps*

This is a painstaking and, as far as it goes, a useful digest of scattered and not very readily available information about China's great river, the Yangtze, which with its 3200 miles ranks after the Amazon (4000 miles) and the Yenisei (3700 miles) as the third longest river in the world. The author's object has been to combine geography and economics; to indicate the part played by the river in the commercial life of China, and to show statistically the share of foreign and Chinese vessels in the carrying trade between the Treaty Ports on the river and in what are technically known as inland waters: those, namely, which link the Treaty ports with places which have not been opened to foreign residence. "Il n'existe pas encore," says Mr. Wang in his preface, "d'exposé systématique de sa navigation sous le rapport de la géographie économique; et, au point de vue de la navigation chinoise, aucun ouvrage non plus n'expose encore l'historique de l'ouverture à la navigation du Yang-tseu et l'état actuel de la batellerie d'après statistiques des diverses sortes de bateaux et de divers pavillons. Actuellement, la question du rétablissement de la souveraineté de la navigation éclate dans toute la Chine."

The last sentence, naturally, has the effect of putting one on one's guard. "A

little propaganda thrown in," one comments; the truth being that, while political China dislikes sharing her coastal shipping with foreigners—most of whom do not allow aliens to share in the carrying trade of their own waters—she is not at present in a position to dispense with the activities and services of foreign shipping companies. No injury therefore is being done to China's economic system by reason of their presence, and such *éclat* as a chauvinistic Chinese foreign Minister might win for himself by excluding foreign vessels from China's coastal trade would derive impressiveness from sentimental reasons only.

Propaganda does not mix well with economics and geography, but as the attempt to combine them is limited to the last chapter of the book, the utility of the whole is not much affected. The other five chapters collect and set out very clearly the results of much previous research, indicating in conscientious footnotes where the various facts come from. But there are gaps. For instance, the author's bibliography does not include the report of the investigations made by Mr. F. Palmer and his colleagues in 1923, nor the studies of the Yangtze Commission appointed by the Chinese Government in 1926, and they are not included in the text. Accordingly, considered as a scientific work, the book is by no means complete or up to date. The shipping statistics are informative and interesting, but some explanation of the origin and scope of the Inland Water Regulations would have made them more intelligible. The statements made on p. 287 purporting to describe attempts by foreign shipping companies to arrest the development of Chinese shipping are incorrect, while the author's general economic conclusions are rendered unreliable by his anti-foreign bias. E. M. G.

UM DEN KANTSCH: der zweite deutsche Angriff auf den Kangchendzönga, 1931. By PAUL BAUER. *München: Knorr & Hirth* 1933. 9½×6 *inches;* 192 *pages; illustrations and maps. M.*10.50

There seems to be a consensus of opinion among British mountaineers that the Bavarian expedition to Kangchenjunga in 1931 accomplished a feat which is likely to remain unsurpassed in this generation. Although an account of their achievements has so recently appeared in the pages of this *Journal* (*Geogr. J.*, November 1932, vol. 80, p. 443, with plates) we cannot forbear to repeat the names of Bauer's team—Allwein, Aufschnaiter, Brenner, Fendt, Hartmann, Leupold, Pircher, Schaller, and Wein—nor to condole with the party on the loss of Schaller, a great mountaineer, who was probably killed by the snow giving way under Pasang, who was roped behind him and fell with Schaller to his death down the terrific face of the East ridge. 'Um den Kantsch' tells the story in eighty-five pages of clear print. There is no padding; nothing irrelevant; and all is set forth with the utmost modesty. Due acknowledgment is made to the assistance given at Calcutta and Darjeeling by the Himalayan Club, and by Messrs. Shebbeare, Gourlay, and Colonel Tobin. The Bavarians appear to have well understood the mentality of their coolies; to have sympathized with their outlook and to have appreciated their excellent qualities; and realizing the indispensability of their assistance, to have taken every possible precaution for their welfare. The Sherpas served them so well that it is obvious that the Bavarians had gained both their affection and their respect.

There are just over one hundred pages of appendices, including articles on the Map and the Glaciers by Dr. Finsterwalder; on the meteorology and on northern Sikkim by Peter Aufschnaiter; on the physiological observations by Dr. Hans Hartmann; on geology by Dr. Kurt Leuchs; and on the Simvu Saddle and the previously unexplored Passenram Valley by Dr. Eugen Allwein. The photogrammetric map by Dr. Karl Wein is an exceptionally fine piece of work. The entire Zemu glacier system, right up to the watershed of all its very

complicated branches, has been accurately plotted on a scale of 1 : 33333 (1 km. = 3 cm.) with 50-m. contours. It will be noticed that in a few places where there was "dead" ground near the stations, or at the head of small subsidiary ice-bays, the contours are marked with broken lines. This gives one great confidence as to the degree of accuracy of the field work: it is indeed unlikely that a higher standard can be obtained under Himalayan conditions. Yet it is but justice to record that Professor Garwood's pioneer survey still constitutes the best map of the whole range.

The book is illustrated by an admirable series of seventy-four photographs, the great majority full-page, taken by several members of the expedition: they are simply but adequately reproduced. The text is well printed in Roman type, for which we are grateful, but it is to be hoped that there will be an English translation of this epic. T. G. L.

AFRICA

A HANDBOOK OF NYASALAND. Compiled by S. S. MURRAY. *London: Published for the Government of Nyasaland by the Crown Agents for the Colonies* 1932. 9 × 5½ *inches;* viii + 436 *pages; illustrations and maps.* 5*s*

This, the third issue of the 'Handbook of Nyasaland,' once more fulfils its purpose as a work of reference in providing the maximum of information within the allotted space, and moreover contrives to exceed the just demand for such volumes by being readable. Of necessity it overlaps to some extent with adjacent lands, for Nyasaland is not a geographical entity. The value of the work is not restricted to the Colony alone, for much of the information is of general interest. History receives its full share of attention: the early settlement, the events leading up to the formation of the K.A.R. and the development of education are adequately summarized; the account of the geology and physiography is good, if not the best yet written, and the two chapters concerned with the Natives and the Tribal Settlements and Warfares have a permanent value. On the other hand, sections dealing with Customs, Tariffs, and Communications are naturally subject to revision in the course of time. Nearly a quarter of the book is taken up with a detailed account of the two Provinces and contains much miscellaneous information varying from the recreations of the European population and the social peculiarities of the native community to Census returns and the boundaries between Districts. It should be noted that an interesting and sympathetic summary is again given of the "Animal and Bird Life," which one would have liked still longer.

The book is excellent and deserves a place on the shelves of all concerned with East Africa; but it is to be regretted that the few pages of Bibliography giving references to the accounts of pioneer travel through this land and the works on Anthropology and Natural History bearing on this part of Africa have not been included for the benefit of those who wish to pursue one of these subjects further than is possible in a short volume. An index corresponding to that provided in the issue of 1922 is also omitted. J. P.

H. M. STANLEY—EXPLORER. By JAKOB WASSERMANN. Translated by EDEN and CEDAR PAUL. *London: Cassell and Company* 1932. 9 × 5½ *inches;* viii + 272 *pages; illustrations and sketch-map.* 12*s* 6*d*

Herr Wassermann has taken the most effective way to revive the memory of a nearly forgotten explorer. He has embodied in one handy well-composed book the gist of the eleven volumes in which Stanley set down at length the episodes of his life. The story makes a complete drama with prologue and epilogue, three

main acts and several entre-actes. The prologue is the account of the unhappy youth as workhouse child, farm-boy, ship-boy, store-clerk; as soldier, first on one side and then on the other in the war of secession; and as reporter in the four great continents. The acts are the finding of Livingstone on the shores of Lake Tanganyika (1871), the long journey from east to west across the dark continent in which was mapped the course of the Congo (1875–1877), and the little-welcomed but successful expedition into darkest Africa for the relief of Emin Pasha and his Egyptian troops (1887–1889). The entre-actes are made up of reporting Napier's advance to Magdala in Abyssinia (1867) and Wolseley's capture of Kumasi in Ashanti (1873) and of governing the Congo Free State (1879–1884). The epilogue is the record of the settled years of his married life which should have been a happy time.

Unfortunately happiness was not in Stanley's nature to achieve. While still young he developed the idea that when he felt attraction to a person that feeling was met by one of repulsion, and there seems to have been something in his nature—possibly a complex derived from ill-treatment in his early years—which made him throughout his life a lonely man always on the defensive and anticipating or sensing hostility. But he had other characteristics, moral and mental, that were admirable—indomitable courage, unconquerable energy, capacity for detailed observation and power of vivid description. His biographer claims for him that he was a leader of men, but does not explain why his leadership of Europeans seems generally to have failed. With one or two exceptions we do not find him able to treat with the confidence due to friends those whose co-operation was essential to him. For most of his great enterprises he made his own selection of his men, and where it was not entirely his own, as in the case of the establishment of the Congo Free State and the Emin Relief Expedition, he would necessarily have had, had he the force to exert it, a decisive voice in the selection. But according to his own account the selections were for the most part failures. The two Europeans whom he took with him to find Livingstone were topers. The three men who accompanied him on his second expedition all died; of one only are we told that he became a friend. Stanley can scarcely find things bad enough to say of the white assistants sent him from Europe to found the Congo Free State. Even to the two whom he liked of those who went with him on the Emin relief expedition—Parke and Stairs—he spoke, after two years of the closest intercourse, as if he lacked confidence in their judgment and even belief in their loyalty. It is fair to add that the former, in a book published some time after the return of the expedition, referred to Stanley's leadership with the highest praise. Stairs avoided taking any part in the acute controversy which went on at that time with regard to the Story of the Rear Column. Neither a book with that title nor Dr. Parke's volume are included in the bibliography at the end of the work under review. Its estimate of Stanley's deeds and character is entirely derived from the explorer's own accounts. In two matters however Herr Wassermann produces theories of his own. He believes that Stanley was deceived by Livingstone's statement that he desired to remain in Africa to discover the sources of the Nile; he thinks Livingstone's real desire was to die in Africa in the exercise of his missionary profession. His other theory is that the failure of the rear column to advance to the support of Stanley was due to the African slave raider Tippoo Tib's successful attempt to debauch the Europeans of that column with the pleasures of a Mussulman paradise. Neither of these theories is backed by convincing arguments, and the main value of the book remains that of a very readable abstract of the explorer's writings. The map which usefully forms the end-papers of the volume is sufficient for its general purpose. The translation is such that no break is noticeable between the English

of the extracts from Stanley and that in which the author's original matter is presented to the reader. Here and there is an unusual word or a word unusually employed. M. N.

NORTH AMERICA

ATLAS OF THE HISTORICAL GEOGRAPHY OF THE UNITED States. By CHARLES O. PAULLIN. Edited by JOHN K. WRIGHT. *Published jointly by the Carnegie Institution of Washington and the American Geographical Society of New York* 1932. 14×11 *inches;* xviii+162 *pages* (*text*) *and* 166 *double pages of plates.* $15

The production of this atlas has itself a considerable history. It was first projected in 1903 by Dr. J. F. Jameson, director of the Department of Historical Research of the Carnegie Institution of Washington, and Dr. Jameson continued to supervise the enterprise until 1927. The development of the project however from 1911 was assigned to Dr. Paullin in 1913, under whose name the atlas has now been published, and who devoted himself to working up the material until 1927. The author had at his disposal the counsel of a large number of specialists and the historical reliability of the work would seem to rest upon the highest authority. There is much evidence of the wisdom of the Carnegie Institution in assigning (in 1929) to the American Geographical Society the task of editing the atlas and arranging for its reproduction, a duty which has been successfully discharged by Dr. J. K. Wright, Librarian of the Society. The maps have been printed by Messrs. A. Hoen and Co. of Baltimore.

It is justly claimed that this is the most comprehensive work of its kind that has yet been published for any country, and indeed the reader's first impression will surely be the remarkably wide scope of the atlas, and its novelty in that it departs in many ways from the traditional historical atlas. The work comprises 162 pages of text, including the index, and 227 pages of maps and cartograms, but while a few plates are double-page maps and many fill a page there are many more pages carrying four, six, or more maps. Thus the authors have been able to deal with a very wide range of subjects within a volume that is neither unwieldy nor—in America—very expensive. The cost has doubtless been kept down by employing colour only where needed for clearness; the result is excellent. No space is wasted in the book, yet there is no crowding. The use of a variety of scales by which so much is accomplished has only one disadvantage—the partial sacrifice of correct sequence in the map series; and this does not seem very material, since the order is preserved in the text. Where the U.S.A. is represented as a whole the scales are either 1/20 M, 1/30 M, or 1/40 M—a good point in an atlas of this kind. The decision to publish text and plates in one binding may well have been based on considerations of cost. But many readers will regret that the two sections were not issued separately to avoid the serious inconvenience in comparing the maps with their descriptions.

All the subjects usually found in historical atlases receive consideration here; but they occupy proportionately less space than would be the case in an atlas, say, of Western Europe. Obviously the illustration of the territorial gains and losses of the various colonial powers is a less complex problem than corresponding changes in Europe. Military history, again, here occupies but 4 per cent. of the space including a plate devoted to overseas campaigns. But this is the first great historical atlas of a continent colonized from Europe (and Africa), and as such it rightly breaks ground in many respects.

The historical maps represent phases of the American people's reaction to their environment. The atlas therefore opens with an account in map and text of the

natural environment—relief, climate, soil, mineral resources, and vegetation—while the country is placed in proper relationship in the Northern Hemisphere by a series of distribution maps on a Polar projection. An early phase of the human history was the exploration of the Continent. The section on cartography includes admirable reproductions, in whole or part, of forty-eight maps, dating from 1492 to 1867, the routes of the explorers being separately represented in colour. The maps devoted to boundary questions are of special interest in that the base used is generally either a reproduction or a redrawing of a contemporary map. A cognate subject which is very fully treated is the allocation of lands to individuals. This has involved the reproduction of another large series of original plans comprising land holdings of great variety of size, type, and location. The text corresponding to all of these territorial illustrations includes a number of appropriate excerpts from treaties, deeds of cession, etc.; and the textual accounts are largely supplemented by bibliographical references, a fact which must enhance their value to the student.

Having thus gained some insight into the manner in which the people first settled on the land, the reader is in a position to study the spread of their descendants across the Continent. He may follow their distribution decade by decade, first their density per square mile, then the grouping of their towns for each period. And he will do well to correlate these maps with some of the large agricultural series as showing, *e.g.* the gradual extension of "improved land." He may turn, if he will, to the section on city plans to see how the later generations, freed from European traditions and settling on the open plains, began the "diceboard" towns that so strikingly mirror the road system and the boundaries of counties and farms in the Prairie states. But the waves of population moving westward are further analysed. Other series of decennial cartograms depict (and the type describes) the origin of immigrants, the percentages of the foreign born and those of the various European immigrants. The influence of the immigrant can next be seen by the mapping of the denominational religion for each of the periods. This in turn prepares the American student for an understanding of his national political history which without such cartography must assuredly be less easy to follow. And it will be well if the cartograms representing political movements induce Europeans to study them and so gain some insight into a political system that puzzles so many. A large group of figures record the results by States of Presidential elections from 1789 onwards. Others deal with Congressional votes on special burning questions of the past—and present; *e.g.* tariffs, declarations of war (1812 and 1917), suffrage, abolition of slavery (1810 to 1865), social legislation of various kinds including prohibition (1845–1920). Finally history that is more purely economic is studied in its different aspects, such as the growth and distribution of manufacturing cities and of the various leading industries; the development of agriculture throughout the period; Anglo-American trade by States (1701–1800), and foreign trade thereafter, also by States. Not least important are five maps showing by isochronic lines the progressive acceleration of travel, and these lead to others depicting the extension of river and canal navigation, of roads, railways, and airways.

The maps and the text, so far as examined, give evidence of prolonged study and sound research upon a host of questions of first-rate importance both to the historian and to the geographer, and few will be ready to doubt the belief expressed by Dr. Wright in his Preface that "the *Atlas* will be a dynamic force in historical and geographical studies in this country for many years to come." This sentence seems to the reviewer to invite a suggestion as to these future studies. The title of the atlas, be it noted, is not 'Historical Atlas,' but 'Atlas of the Historical Geography of U.S.A.' Now if geographical opinion is at last

tending to give some definition to the aim of *geographical* research in relation to history, it is surely in the direction of presenting the regional geography of former periods. We may therefore perhaps be permitted to hope that the co-operation of the Carnegie Institution and the American Geographical Society, so happily begun, will be continued later on in the production of supplementary atlases dealing for example with the geography of the various Indian tribal territories when first explored; with Virginia and New England in the seventeenth century and the later eighteenth century, and so on. We can at least rest assured that the union of American historians and geographers so effectively contrived will not easily be dissolved while this monument stands. A. G. O.

NONSUCH: land of water. By WILLIAM BEEBE. *London: Putnams* 1932. 9×6 *inches;* xvi+246 *pages; illustrations.* 21*s*

Perhaps it is hardly fair to judge this book as a serious contribution to natural history, seven of the fifteen chapters having already appeared in various American monthly magazines. Nonsuch is a tiny islet of Bermuda which served the author as a base for the study of marine life. An excellent aerial photograph of the island faces p. 128, showing an imposing array of buildings—the laboratories of the Department of Tropical Research of the New York Zoological Society, of which Mr. William Beebe is the Director. He has much that is fascinating to tell, and we wish he could have written of it in more simple language. A naturalist's book should be a straightforward recitation of facts; the simpler the language, the greater the charm of the work. This one loses much through the extravagance of the language in which it is written. A piece of descriptive writing from p. 149 is typical: "The sea was quiet, not even old enough to be stagnant, but as still as ever water can be. Even the sunrise, having attained an exquisitively subdued brilliance, hung fire in cosmic suspense, and I also held my breath. There was not a feather of wind—the air was immovable and therefore unthinkable; weather was on dead centre."

Despite this serious drawback of style the book is interesting and tells of novel experiences such as "slicking for Flying-Fishes and sub-marine diving in search of the wonders of the deep." Many brilliant fishes and curious sea plants which abound in the Bermuda seas are described and glimpses of their life histories made known. The forty-six photographs are excellent and instructive, that opposite p. 164 of a Shark-sucker clinging to the breast of a shark being exceptionally good.

This book contains little of purely geographical interest. "These Chapters," we are told in a Foreword, "wrote themselves in the intervals of diving, fishing, watching, naming, dissecting—the serious study of the fish of Bermuda." It is not surprising therefore that they lack continuity and finish. D. A. B.

ETOWAH PAPERS. I. Exploration of the Etowah Site in Georgia. By WARREN KING MOOREHEAD. II–V [by others]. *New Haven: Yale University Press (for the Department of Archaeology, Phillips Academy, Andover, Mass.); and London: Humphrey Milford* 1932. 11×8 *inches;* xii+178 *pages; illustrations and maps.* 22*s* 6*d*

General and indeed professional interest in the history and archaeology of the native civilizations of the United States has been largely focussed on the Puebloan and related cultures of New Mexico and Arizona in the south-west. At the time of European discovery however the native Muskoghean peoples of the south-east in the Mississippi valley and Gulf—Atlantic states were probably far more numerous and had as elaborate a culture. But the eastern position and greater fertility of their territories brought destruction on the native peoples, institutions,

and crafts of this area far earlier, and European settlement has over the greater part long obliterated almost every trace of Indian life.

The south-eastern United States was the scene of a group of related civilizations of settled maize-cultivators which probably reached their climax some time before the arrival of the Spaniards. The most important surviving monuments of this phase are the large earthen mounds or temple platforms which are to be counted in their thousands in the Mississippi and Ohio basins. Earthen platforms with spiral ramps or wooden staircases were still being built in the sixteenth and seventeenth centuries. On them the Spanish and French explorers found large timber-built temples and chiefly houses which dominated the town sites. The pre-Columbian Mound-builders and the historic Indians of the south-east were skilful workers in stone, shell, and beaten copper. Our knowledge of the social and economic life of the south-eastern peoples has been greatly advanced by Swanton's extensive collation of the manuscript records of Spanish and French explorers with field investigations among surviving groups. The archaeological investigation of Mound-builder sites in recent times owes much to the energy of Mr. Moorehead, of the Department of Archaeology of the Andover Academy, Massachusetts, and this volume contains a number of short reports by several workers on the results of excavations in the village site at the famous groups of mounds at Etowah, in Georgia. The high quality of the pottery, hammered copper, and shell-inlay ornaments that were found here by systematic excavation confirms the richness of the south-east as revealed by the stray finds and more haphazard investigations of a generation ago, while further examples of relations between southern Mound-builder art and that of Southern Mexico have been recovered. As a tentative solution of the problem posed by the complete absence, so far as is at present known, of mounds or art forms showing Tolec-Aztec or Maya influence over the 1500 miles between Southern Mexico and Louisiana (the western limit of the Mound-builder culture) Dr. Moorehead suggests that contacts and migration *via* Yucatan, Cuba, and Florida are more probable than connections through north-east Mexico and Texas, and would account for the greater wealth of the Eastern Muskoghean area.

C. D. F.

AUSTRALASIA AND PACIFIC

THE JOURNAL OF THOMAS WILLIAMS, MISSIONARY IN FIJI, 1840–1853. By G. C. HENDERSON. *Sydney (Australia): Angus and Robertson* 1931. Two volumes. $9\frac{1}{2} \times 6$ *inches;* lii+606 *pages; illustrations and maps.* 25*s*

The Professor of History in Adelaide University has made a detailed study of the life of Thomas Williams, one of the great pioneer missionaries of the Pacific Ocean: one is almost tempted to say too detailed a study, for in the long introduction we are even given the history of Williams's birthplace in Lincolnshire. The two volumes consist mostly of the diary in which Williams described his thirteen years in Fiji. It is given as a whole with the exception of certain purely formal entries as to places and subjects of sermons and similar matters of small historical importance. Professor Henderson gives a large number of helpful explanatory footnotes. He does not obtrude his own views on the outlook of missionaries on primitive peoples, but it is nevertheless made apparent, both in the introduction and in a few of the footnotes, that he considers that Williams was unnecessarily severe in his condemnation of the character of the unconverted natives. Indeed this is confirmed by the diary itself. It was however probably natural that a Methodist missionary of 1840 should not regard unchristian religions in a favourable light. Less religious people might easily have been

shocked at many of the appalling cruelties recorded in this book. If we disregard this slight uncharitableness, or narrowness of outlook, there remains only admiration for a brave man who worked against almost insuperable odds, which at one time nearly caused even him to despair. On almost every page something of real interest is recorded. A few photographs taken recently in Fiji are included, but they are unfortunately poor. J. R. B.

UNTOLD MILES: three gold-hunting expeditions amongst the picturesque borderland ranges of Central Australia. By MICHAEL TERRY. *London: Selwyn and Blount* [1933]. $9\frac{1}{2} \times 6$ *inches; 288 pages; illustrations and maps.* 18*s*

The untold miles numbered nearly 2000 passed over by a Morris truck in the course of three prospecting expeditions. The first was of some 900 miles west from Horseshoe-Bend on the Adelaide–Alice Springs Railway to the western end of the Petermann Ranges on long. 129° E., which forms the boundary between Central and Western Australia; the second was of about 550 miles from Oodnadatta on the same railway to the Tomkinson and other ranges extending another degree farther west; and the third of nearly 500 from the terminus of the West Australian Kalgoorlie–Laverton Railway north-east to the Warburton Ranges, some 70 miles west of the Cavanagh Ranges reached in the second expedition. The first two expeditions occupied from July 1930 to January 1931, and the third from April to July, inclusive, of the latter year. In the first the transport afforded by the truck was supplemented by eight camels with a black boy to lead them, a transport combination for which a good case is made out when the country is such as to limit the truck's progress to some 120 miles per six-day week. For the third expedition only a truck was available, sole reliance on which is risky on rough land with uncertain water supply. In all three journeys the author was in charge of the party and had Bill Bird, a prospector, and another white man with him. Billy Williams was head prospector in the first, Louis Charles Bailey in the second, and Jack Young in the third expedition. Ted Colson looked after the camel transport in the first. "Each of the five . . . is a man all men would be glad to call friend." This sentence, written after the expedition had been through many a tight place, justifies record of the names being here made, and indicates the relations maintained between the members of the party. Those with the Endeavour Company that financed it seem to have been equally cordial. The results must however have been disappointing to that Company. Only in two instances, towards the end of the third expedition, in the course of six weeks' prospecting in the greenstone belts of the Warburton Ranges, was a very fine tail of gold traced in the pan, and this was not considered sufficient justification by the Company for further prospecting in the same district, at any rate for the time being. From a national point of view the expeditions were more fruitful. Geographical and geological notes and observations were taken over a large area and recorded, the leader rightly attributing importance to pioneers setting down on paper their additions to discovery. For those who will in the future travel by car or truck in the ranges traversed in 1931–32, the account of the manner in which difficulties were overcome in the different classes of country—dry sand, fallen and standing scrub, boulder-filled stream-beds, boggy soil—will be useful, and so also will be the description of the methods adopted for finding, getting, and carrying water. Stress is laid on the quickly changing aspects of the country under different weather conditions and on the beauty of much of it, especially of the great peaks and hill-encompassed valleys of the borderlands of the three States. These are included in the 65,600 square miles of native reserve, some of which Mr. Terry and his companions would like to see taken for stock-raising. Excellent cattle-feed grows on it, but it is also most

suitable country for native settlement. The appearance, characteristics, and outlook of the wild blackfellows who are there are excellently described, and the manner in which they were treated by the prospecting parties—accepting their friendliness but keeping them clear of the camp—was doubtless judicious. More difficult to keep at a distance were the animal pests of all sorts—mice, flies and sandflies, ants and fleas which militated against rest and sometimes interfered with work. For the prospectors much of this consisted of collecting specimens and of loaming or testing the material scratched off a formation, and of dollying or testing reef specimens reduced to powder. The technical work of the expedition, described very shortly in the text, is given prominence in reports published as an appendix. Another appendix usefully records the names of geographical features; it is to be regretted that there is so little of poetry or melody in these names ("Pararie" Mount from the native word for "far-away" is an exception) and also that the spelling in this appendix, in the text, and in the maps does not always correspond. The maps might with advantage have been rather more clearly drawn. Here and there the writing of the book is a little careless, but it is good reading, and where conversations are reported verbally they are in good Australian. M. N.

PHYSICAL AND BIOLOGICAL GEOGRAPHY

TROIS RÈGLES FONDAMENTALES DE L'ARCHITECTURE DE l'Écorce Terrestre. By P. FOURMARIER. (Bibliothèque Scientifique Belge.) *Paris: Hermann et Cie* 1932. 7½ × 5 *inches; 138 pages; sketch-maps.* [4s 6d]

Professor P. Fourmarier is well known to geologists for his researches on the tectonics of the Ardenne and the Belgian coalfields, and he has also dealt with the geological structure of larger areas of the Earth's crust. In this little volume he summarizes his views on the structure of the crust as a whole. He recognizes three fundamental laws, which he calls the law of permanence, the law of parallelism of successive deformations, and the law of symmetry. The first law states that certain parts of the crust have remained rigid from very early geological times, while intervening areas have at intervals been subject to folding, an assertion which no geologist will dispute. With regard to the second law the author does not explain what he means by parallelism upon a sphere. It is evident that the law is limited in its application and he is not very successful in showing that the Caledonian and Hercynian systems are parallel in any sense of the word.

About half the volume is devoted to the law of symmetry. Many years ago Suess drew attention to the striking resemblance between the Canadian and Baltic Shields and showed how the one is a remarkably faithful reflection of the other, about a line drawn from north to south through the North Atlantic. Fourmarier tries to carry the idea farther and considers that this line is an axis of symmetry throughout the Atlantic and that a similar axis of symmetry runs from north to south through the middle of the Pacific. Both axes are somewhat curved and they meet across the Arctic Ocean and the Antarctic Continent. A third axis of symmetry lies along the Urals and is continued in the Indian Ocean, while a fourth, nearly at right angles to the others, runs through the Caribbean and Mediterranean Seas.

A rude symmetry about the Atlantic and Pacific axes has been noted by previous writers, and the Caribbean–Mediterranean line was an important feature in Lowthian Green's hypothesis. He attributed it to torsion of a southern and a northern hemisphere with respect to each other. Fourmarier develops his ideas in an interesting fashion, but the small size of the book prevents any critical discussion and consequently the degree of symmetry is exaggerated. P. L.

MORPHOLOGIE DES TOSKANISCH-UMBRISCHEN APENNIN. By RICHARD PFALZ. *Leipzig: Robert Noske* 1932. $8\frac{1}{2} \times 6$ *inches;* vi+122 *pages; illustrations and sketch-map. M.*7

The area described in this booklet includes the Arno and the Tiber, and even a school atlas shows that the courses of these rivers are abnormal. On the western slope of this part of the Apennines the rivers do not flow directly to the sea but turn for long stretches into valleys which run almost parallel to the range and which are of tectonic origin. In Pliocene times the sea reached the foot of the range and sent offshoots into some of these longitudinal valleys, as in Dalmatia at the present day.

The author gives a detailed account of three strips of country: (1) a transverse strip stretching from Faenza, at the eastern foot of the Apennines, through the Florence basin to the mouth of the Arno; (2) a longitudinal strip from Florence through the Val d'Arno and Val di Chiana to lake Trasimeno; (3) another longitudinal strip along the upper Tiber to Perugia. The Pliocene sea reached the ridge at Lastra which closes the Florence basin on the west except for the gap through which the Arno flows. It also extended into the southern end of the Val di Chiana; but elsewhere in the strips described the Pliocene and Quaternary deposits are of terrestrial origin, fluviatile, lacustrine, swampy, or wind-blown. There are interesting loess-like sediments, indicating a drier climate during part of the Quaternary period, and Dr. Pfalz thinks that for a time some of the longitudinal depressions were without an outlet for their waters. The present connections and the connection of the Florence basin with the Lower Arno were due to erosion at the head of streams flowing down the old watersheds. The Upper Arno originally reached the sea through the Val di Chiana, but elevation in the Trasimeno region deflected it into the Val d'Arno which by that time had been connected in the manner described with the Florence basin. The Italian geologists attribute more influence to antecedence and much less to backward erosion, and accordingly reach different conclusions.

About half the book is occupied by a discussion of general principles based on the author's observations in this area. There are eighteen photographic views, six outline sketches, and two small maps of the area in black and white. What the reader misses most is subsidiary maps on a larger scale to help him in following the detailed descriptions. P. L.

TRANSACTIONS OF THE AMERICAN GEOPHYSICAL UNION. Thirteenth Annual Meeting. April 28 and 29, 1932. *Washington, D.C.: Published by the National Research Council of The National Academy of Sciences, June* 1932. $10 \times 6\frac{1}{2}$ *inches;* 402 *pages; illustrations and maps*

The number of papers contained in this report is so large that it is impossible to refer to more than a few of them. As a whole it is a sign of the growing interest in oceanography taken in the United States, for 130 pages out of 300 are devoted to this subject. The General Assembly held a symposium in which it discussed the application of the geophysical or seismic methods used in prospecting for oil to the investigation of ocean basins. In connection with the question of the formation of the basins by the sinking of their beds one speaker pointed out that if it could be shown that the Palaeozoic mountains of Cornwall and Newfoundland were continuous along the sea bottom, then it was highly probable that the bed had sunk, and at the same time Wegener's drift theory became untenable. The modern deep-sea echo sounder with automatic recorder should go far to settle this problem. A similar symposium was held in the Section of Seismology.

In the Section of Oceanography an account was given of the radio acoustic methods used by the United States Coast and Geodetic Survey for fixing the

position of ships engaged in sounding. In the course of this work it was found that the most correct velocity of sound in sea-water for this purpose was the one calculated from the bottom temperature and salinity.

Commander E. H. Smith, at one time oceanographer of the Ice Patrol, presented a programme for work leading to a quantitative determination of the interchange between the Arctic and Atlantic Oceans, and stated that the *General Greene* Expedition in 1931 had found that the water in the eastern half of Davis Strait was much warmer and salter than that found there by the *Marion* in 1928. P. E. Church had found that thermograph records made in various ships showed that there was no good evidence for large changes in the position of the Gulf Stream, although eddies of warm water were thrown off from its northern edge, where it flows north-eastwards along the American coast.

The programme of the Section of Hydrology was also very large and dealt with run-off, soil permeability and soil moisture, and flood phenomena. A paper by H. K. Barrows on the Velocity of Flow of Natural Streams should be of interest in this country in connection with the work of the Rivers Pollution Board.

In the Section of Vulcanology, G. W. Morey stated that he had been unable to detect any certain volatilization of silica in high-pressure steam at 490° C. Previous investigators had recorded volatilization of as much as 0·3 gramme under comparable conditions.

The Section of Geodesy discussed gravity measurements and methods used in aerial survey, and in the Section of Terrestrial Magnetism and Electricity the larger number of the papers dealt with atmospheric ionization and the conditions affecting radio transmission. D. J. M.

ECONOMIC AND HISTORICAL GEOGRAPHY

THE ART OF TOWN PLANNING. By HENRY VAUGHAN LANCHESTER. (Universal Art Series. Edited by FREDERICK MARRIOTT.) Reissue in cheaper edition. *London: Chapman and Hall* 1932. (First published 1925.) 9×5½ *inches;* xx+244 *pages; illustrations and plans.* 10*s* 6*d*

TOWN AND COUNTRYSIDE: some aspects of urban and rural development. By THOMAS SHARP. *Oxford: University Press* (*London: Humphrey Milford*) 1932. 10½×7 *inches;* xii+228 *pages; illustrations and plans.* 15*s*

Town planning, one of the most urgent responsibilities of civilization at the present time, is so much everybody's concern that its literature should be sure of a wide public. In 'The Art of Town Planning' Mr. Lanchester approaches the problem as a historian and a craftsman, and although the first qualification seems to endow him with almost too dispassionate an outlook, and the second to bring him rather too close to his subject for a perspective view of it, its problems are admirably explained and illustrated, and with so much sympathetic understanding that his book should prove a popular introduction to the subject.

Stimulated to further study the reader would do well to follow it up with 'Town and Countryside' and to find in it a valuable commentary on Mr. Lanchester's reading of the same problems, and incidentally a timely corrective to any complacency or optimism which it may have encouraged. By including the Countryside within the scope of his inquiry Mr. Sharp considers town planning as part of a larger and more fundamental issue. The results of a generation of well-meaning experiment are passed in review, and a brilliant diagnosis achieved of the mischief and devastation brought about during some twenty years of doctrinaire reform. The assumptions on which such doctrines

have been so comfortably based are exposed to a searching analysis, and after what Mr. Sharp has to say about certain accepted commonplaces, of which the theory that the Englishman is temperamentally insensitive to urban values is perhaps the most foolish and mischievous, it is to be hoped that they may be withdrawn from circulation. Mr. Sharp's searchlight certainly reveals a prospect of confusion and drabness unsuited to the emergency and unworthy of English traditions, talents, or intentions; but it is impossible to read his Jeremiad without stimulation, or without feeling that his message has just those simplifying and quickening properties which might still provide the sense of direction necessary to save the situation. G. L. K.

A HISTORY OF THE GEORGIAN PEOPLE, from the beginning down to the Russian Conquest in the Nineteenth Century. By W. E. D. ALLEN. *London: Kegan, Paul, Trench, Trubner & Co.* 1932. 10×6 *inches;* xxiv+430 *pages; illustrations and maps.* 31*s* 6*d*

Mr. Allen has performed a useful task in attempting to give the first full account in English of the history and civilization of the Georgians. He is equipped with an admirable knowledge of the Georgian language and has studied the various recent Russian and Georgian works on the subject. His book gives an account of the historical geography and the full history of Georgia from prehistoric times. Where he deals with his own travels in Georgia he is interesting and illuminating. Unfortunately as historical geography his work is marred by the fact that his maps do not show the mountain ranges—a serious defect when treating of a country whose evolution has entirely depended on the lie of the mountains. As a historian Mr. Allen shows a lack of proportion; facts are crowded together without any apparent appreciation of their significance, and this, combined with an unhappy passion for "fine writing" and philological pedantry, makes his book very hard to read. The accuracy of the facts need not be questioned. A greater knowledge of Byzantine history might have saved Mr. Allen from one or two unwise generalizations; and one would have been grateful for a fuller account of Georgia's position on the trade-routes of the early Middle Ages and of the Georgian influence on Russian architecture. Mr. Allen provides some valuable chapters on the organization and administration of the Georgians. But Brosset's works will, I think, despite subsequent research, remain the standard authorities on the subject; for, though "scarcely palatable to the lay reader," as Mr. Allen states, they are at least soberly and unselfconsciously written.

The illustrations, taken chiefly from the MS. of the Dominican Castelli at Palermo, are delightful. S. R.

BOHEMIA IN THE EIGHTEENTH CENTURY. By ROBERT J. KERNER. *New York [and London]: The Macmillan Company* 1932. 9½×6½ *inches;* xii+412 *pages.* 20*s*

The sub-title of this book is 'A Study in Political, Economic, and Social History with Special Reference to the Reign of Leopold II, 1790–1792.' The period is the middle phase of the three centuries' eclipse of Bohemia that lasted from the Battle of the White Mountain in 1620 to the Declaration of the Czechoslovak Republic in 1918, and was treated in somewhat summary fashion in the historical sketches in English by C. E. Maurice and Count Lützow; in fact, the reign of Leopold II occupies only a few lines in those works. Professor Kerner, of the University of California, has made an intensive study of the archives of Vienna and Prague, particularly of the documents connected with the Desideria or demands presented by the Bohemian Estates at the Diet of

1790. He describes the internal changes—political, economic, and social—in Bohemia under the centralizing and Germanizing policy of the Habsburgs. "The forces which resulted in making Bohemia officially German and in reawakening the sleeping Czech nation confronted each other in 1790." References to original documents are plentiful, and there is a very full study of the bibliography.

Apart from the obvious importance attaching to Bohemia's geographical position at the heart of the Habsburg empire and indeed of Europe, there is little in the book that can strictly be called geography. In the chapter entitled "Bohemia in 1790" there are some interesting statistics of the population, which was denser, wealthier, and economically more advanced than in any other Habsburg state. We are told that it had increased 42 per cent. in little over a generation, with a yearly surplus of births over deaths amounting to nearly 50,000. The total in 1791 was about 2,800,000, of whom two-thirds were Czechs and one-third Germans. The author estimates that the agrarian population forming the Fifth Estate amounted to 82 per cent. Prague was easily the largest city with over 70,000 inhabitants, being far in advance of the largest city in Hungary, with 29,000, but far short of Vienna's 270,000. Pilsen came second with 8000–12,000, but no other city mustered over 6000. The omission of a political map of the period is noticeable in a work of such thoroughness.

J. H. R.

ITALY IN THE MAKING, 1815 to 1846. By G. F.-H. BERKELEY. *Cambridge: University Press* 1932. 9×5½ *inches;* xxx+292 *pages; illustration and maps.* 15*s*

The Italian "Risorgimento" is mainly known to English readers through the inspiring pages of Professor Trevelyan. Those who wish to study the antecedents of the stirring events therein recounted will do well to read this work of Mr. Berkeley's, which covers the period from the Congress of Vienna to the election of Pio Nono. All the influences working for and against the conversion of Italy from a geographical to a political expression are clearly analysed. The author strives to do justice to all, though it is obvious that his sympathies are with the moderates, even slightly inclined towards the Papal side. He certainly is not an enthusiast for the Mazzinian school, whose true importance was only displayed after the period with which he deals. The effect of the Napoleonic period upon the idea of national unity might also have received rather more consideration. The enigmatic character of Charles Albert of Savoy-Sardinia receives sympathetic interpretation. The book is thoroughly documented, and makes very agreeable reading.

G. R. C.

GENERAL

A FRENCH-ENGLISH VOCABULARY IN GEOLOGY AND PHYSICAL Geography. By G. M. DAVIES. *London: Thomas Murby & Co.* 1932. 7½×4½ *inches;* x+140 *pages.* 6*s*

This book will undoubtedly be of use to English readers of French works on Geology, Geography, and allied subjects. As the author says, it is the commonplace words used in a semi-technical sense that are most likely to prove stumbling-blocks to English readers: for example, such words as *anse*, *arête*, *assise*, *aval*, *dalle*, *décrochement*, *gradin*. One is particularly grateful to him for pointing out the many different meanings that can be attached to the word *schiste*, so often mis-translated into English. The author is also probably doing a service to those whose knowledge of French is elementary, when he calls attention to possible

pitfalls by giving a suite of words of similar appearance, as: *palme, palmer, palmier;* although there are a number of words that might well have been dispensed with in order to make possible the inclusion of a more useful selection. No schoolboy who has learnt French for two or three years should have any difficulty with such words as *valeur, unité, tonnerre, lourd, natation, neige, ouverture*, used in their ordinary sense; while one could suggest a long list of less well-known expressions: *cru* (in the sense of native soil), *pacage, cep, mûre, bûcheron, pise, échine, pré*, to give a few examples. Perhaps it would add to the value of the vocabulary if the word giving the specialized sense were printed in italics, *e.g.* REMANIE, rehandled, *derived.*

We hope that future editions will make this little volume as useful to the geographer in geographical terms as it will certainly prove in terms relating to geology. H. O.

COLLEGE GEOGRAPHY. By EARL C. CASE and DANIEL R. BERGSMARK. *New York: John Wiley & Sons; London: Chapman and Hall* 1932. $9\frac{1}{2} \times 6$ *inches;* xiv+700 *pages; illustrations and maps.* 28*s*

This well-illustrated and well-produced commercial geography follows the plan which of recent years has been increasingly popular in this country, in that it treats of the world as a whole divided into major natural regions. The first four chapters, pp. 1–136, are devoted to general principles. The longest section of the book, pp. 137–522, is then devoted to a consideration of the world on the basis of the natural divisions. Some of the titles given to the regions are unfamiliar, and one rather regrets the use of the name "Tropical Rain Forest" for what are rightly, and more usually, called Equatorial regions. The "Corn Belt type" of climate is made to include the Corn Belt of the United States, south-eastern Europe, northern China, and southern Manchuria, and does not seem a very happy choice. The latter part of the book is devoted to the seas and their products, mineral industries, transportation, and international trade. It is to be feared that the method adopted in this case has resulted in a very scrappy treatment and there are some remarkable gaps in the information. Under petroleum no mention is made, except in the form of a rough diagram, of any producing country outside the United States. The British Isles are particularly unfortunate in that the incidental references are rarely of more than a few lines. Thus agriculture in England, Wales, and north-western France is dismissed in ten and a half lines. But the most serious defect of the book is the superficiality of so many of the statements. Generalizations are made which tend towards the picturesque but which are quite definitely inaccurate. Thus, on p. 138: "until very recently would-be colonizers and developers of the rain forest have met with tragic defeat. The decaying remnants of ambitious projects to-day give witness to the hopeless struggle of many people who have settled here"; but there is no reference to Java. It is typical of numerous careless statements to say "London, located on the Thames and *in the heart of England*" (p. 644), "the coal reserves of the United Kingdom are large enough to supply her probable needs *for several more generations*" (p. 584) (the official estimate is four to seven centuries). On p. 372 in the general description of the regions of marine climate it is stated, without reference to seasons, that "fogs are prevalent along all the coasts and are a great menace to shipping. In London, farther inland, fogs are a commonplace. As the milky billows roll over the city all becomes darkness and confusion. Lights must be turned on in midday, traffic is slowed up—almost stopped, and congestion of the worst kind results. In the business districts millions of dollars are lost in sales." L. D. S.

LEAVES FROM AN UNWRITTEN LOG-BOOK. By Captain WALTER H. PARKER. *London: Sampson Low, Marston & Co.* [1931]. 9½×6 *inches;* xvi +272 *pages; illustrations.* 12*s* 6*d*

This is a plain and unassuming record of a remarkable career. Captain Parker regrets that he never kept a private log, but it is doubtful whether his story, depending on his unaided memory, is not therefore the more entertaining. Entering the Merchant Service at the age of thirteen in 1882, he passed the first twelve years of his sea life, including his apprenticeship, "in Sail," and the first hundred pages of the book, dealing with this period, are crammed with such furious encounters and hairbreadth escapes as will surely cause many boys to regret it is now hardly possible to go to sea as apprentice in a windjammer. Six years of rough and tumble in small and usually grimy ships, six more as the energetic and fire-eating mate of trim clipper barques, and the boisterous ardours of "Sail" are exchanged for a less exciting but more profitable career "in Steam." Even so, life still has its joyful occasions for, though in recording this part of his life the writer adopts the ancient sundial motto, the serene hours chronicled in the very first chapter comprise the biggest and fiercest scrap and the most hair-raising storm of his experience. Nevertheless a more tranquil atmosphere has its effect, and thirteen years with the P.S.N.C., varied by two spells in the Royal Navy, including active service during the Chinese Boxer upheaval, transform the swashbuckling mate into the urbane and cultured captain of a liner, flying his R.N.R. flag and in charge of His Majesty's Mails. Captain Parker disposes of his war experiences in one short chapter, passing modestly over the eminent services as Captain R.N.R. and Commodore of Convoys that earned him his country's gratitude and the recognition of his Sovereign. The years that follow bring increasing success as, passing from fine to finer ship, the sailor attains the summit of his profession, commanding the largest British liner afloat before retiring full of honours and surrounded by friends. The book is well made and pleasant to read, and such small misprints as occur are scarcely noticeable in the graphic style and easy flow of the writer's composition. The illustrations, some from clever drawings by the writer, are satisfactory. There are no maps and there is no index.

W. A. G.

THE TRAIL THAT IS ALWAYS NEW. By WILLOUGHBY P. LOWE. *London: Gurney and Jackson* 1932. 9×6 *inches;* xviii+272 *pages; illustrations and sketch-maps* (*by* H. G. GRÖNVOLD *and* J. P. W. LOWE). 16*s*

This is the travel record of a naturalist-collector in many and varied parts of the world. His work has brought him to the Rocky Mountains, East and West Africa, Burma, Siam, the Philippines, and Madagascar, from which countries he has enriched the bird room of the British Museum with over ten thousand specimens, many of which were new to science. Such work necessitates visiting unfrequented districts; hence the many curious and unusual incidents in his record are likely to be of special interest. Animal life naturally receives chief attention, and there are many references to the distribution of birds. But the character and scenery of the countries and the customs of the people also receive due consideration. Some of his natural history observations are of striking interest, especially that of a vast gathering of sea-snakes—no doubt a breeding-assemblage—making a band some 10 feet wide and 60 miles long, which he encountered off the coast of Sumatra. Without exaggeration there must have been millions in the assemblage; and they belonged to a rare variety! The book closes with a series of useful hints on the preservation of health in tropical countries.

R. W. G. H.

THE MONTHLY RECORD

NEW EDITION OF 'ALPHABETS OF FOREIGN LANGUAGES'

The stock of this publication, which was *No.* 2 in the *R.G.S. Technical Series* and first appeared in 1921, having been exhausted, the opportunity of a new issue has been taken to give the existing matter a thorough revision and at the same time to make some important additions. The Rules for Spelling termed the R.G.S. II System required a certain amount of amendment, chiefly in the direction of providing better examples than those originally given which for one reason or another had become inapplicable. These Rules of course do not apply to those languages that officially employ the Latin alphabet with or without diacritical marks; the R.G.S. II equivalents given in the tables of such languages are intended to be explanatory of the pronunciation and not to be employed for transcribing names for English use; for this reason the possibly misleading words "Transcribed into English" have been removed from the original title of the book. Where an alphabet other than Latin is employed, as in Russian, Arabic, or Hebrew, the R.G.S. II column in the table shows the transliteration recommended for actual use, and peculiarities of pronunciation are explained in the margin. Since the first edition the Turkish language has moved from the latter category to the former; and consequently the article on Turkish has been entirely rewritten; a brief grammatical note has been added to explain certain formations in Turkish names. In the miscellaneous group there are two additional languages; the article on Afrikaans describes the main differences between Cape and European Dutch, while that on Maltese explains at some length the orthography adopted for Government publications.

Without going into elaborate phonetics the book forms a practical guide to the pronunciation of all the European and the principal Near-Eastern languages, with geographical examples, and to ensure accuracy competent natives as well as British scholars have been consulted in nearly every case. Its price remains unaltered, namely 7*s* 6*d*, to Fellows 6*s*.

NEWS FROM THE LAKE FJORD PARTY IN GREENLAND

When after reporting the death of Watkins his three companions, Rymill, Chapman, and Riley, returned from Angmagssalik to Lake Fjord they found Captain Mikkelsen there and the house which he had promised partly erected (*Geogr. J.*, vol. 80, p. 549). By the courtesy of *The Times* we are enabled to print the following abstract of a message dated Angmagssalik, February 25, which will have been published in full before this *Journal* appears. They soon finished building the house, and an abundance of salmon enabled them to lay in good supplies for the winter. In November successful seal hunting from kayaks increased their supplies, and they had enough to lay out a depot at the head of Kangerdlugsuatsiak Fjord in preparation for a spring journey. The continued absence of pack-ice outside, and the consequent heavy swell, kept the water open till the latter half of November, and made boat journeys difficult; but they had been able to communicate several times with Eskimos in the next fjord and to obtain seal and skin clothing.

The winter had passed comfortably with abundant fish, seal, bear, etc., to supplement the stores which Captain Mikkelsen had left with them to guard against a possible shortage from hunting. There had been no gales, but heavy snow with occasional warm spells and rain, and little survey had been possible during the winter. On February 7, leaving Riley to carry on the meteorological work, Rymill and Chapman started to sledge down the coast to Angmagssalik,

finding the going over the pack-ice very heavy. On February 13 they had much difficulty with the ice opening below their camp, but after an adventurous journey they reached Angmagssalik about February 20 and were intending to return to Lake Fjord with fresh dogs and to start for Kangerdlugsuak, attempting the ascent of Mount Forel and other survey journeys later.

NOXIOUS FOG IN THE MEUSE VALLEY

In the course of a series of articles on the fogs of the city of Lyons, André Allix devotes one of them to a consideration of the fatal fog which, it will be recalled, caused an alarming amount of illness and death in the valley of the Meuse in Belgium in the early days of December 1930 (*Études Rhodaniennes*, vol. viii, 1932, nos. 3–4). A commission of inquiry which was appointed to investigate the circumstances of the catastrophe fortunately arrived at very decisive conclusions which were communicated to the Belgium Academy of Medicine.

A summary of the principal results makes it clear that for more than three days there prevailed in a confined and highly industrialized portion of the Meuse valley, extending for about 20 kilometres above Liége, a very dense fog drifted by a light wind from the north-east in which direction the valley trends, and that both the natural fog and the chimney products with which it was charged were kept concentrated on the valley floor by what is known as a "temperature inversion," that is, warmer air overlying intensely cold surface air. But the critical factor in an unusual combination of factors is shown to be that the fog was charged with sulphurous and sulphuric acid to a degree of concentration which proved fatal because it lasted for more than a few hours, though a much greater concentration might have been borne for half an hour without fatal results. The writer goes on to show that it would be quite possible for a similar combination of factors, meteorological, industrial, and topographical, to give rise to a like calamity in Lyons, and he also refers to London in this connection. We think however that such a contingency is much less likely in London, partly because the Thames valley is far more open, partly because London fogs have largely lost the choking pungent flavour so noticeable in Victorian days, and partly because the more unstable meteorological conditions in England are less favourable to persistent fogs of this type for days together than on the Continent.

CLIMATE OF IBERIAN PENINSULA

In *Ann. Hydrogr. Berl.* Dr. W. Semmelhack gives a useful discussion of climatological data for Spain and Portugal scattered in various publications between 1850 and 1925, the rainfall being dealt with in Heft I, and the temperature in Hefte VIII and XI of the serial for 1932. The region is described as partaking more of the character of a self-contained continental unit than of a peninsula, the Mediterranean climate in the interior of Spain being, in fact, modified almost to the point of subversion. The Castilian plateau at altitudes between 2000 and 3000 feet is subject to severe winter cold with fierce snowstorms and night minima below 0° F. In summer most parts of the peninsula are liable to maxima of 105° F. and upwards, but the hottest area is the basin of the Guadalquivir, where Seville has a mean temperature in July and August as high as 86°, frequent maxima over 110°, and an extreme record of 122° in 1881. Isothermal charts based on seventy stations showing the mean temperature for the twenty-year period 1881–1900, both actual and reduced to sea-level, are produced. The large extent of tableland in the peninsula renders the drawing of actual isotherms more manageable than is the case for some countries, but the chief interest of the reduced isotherms is in illustrating the sub-continental seasonal variation. The latter in winter increase from the centre outwards as well as from north to south,

the coldest area being in north-central Spain, whilst in summer they decrease outwards as well as northward with the hottest area in south-central Spain. These features, as the author points out, suggest that Spain is the theatre of a distinct monsoonal type of air circulation which is borne out by the average wind and pressure charts. In January there is a definite centre of high pressure over Spain between Atlantic and Mediterranean low-pressure areas, whereas in July a shallow low-pressure centre modifies in Spain the expansion over the Mediterranean of the Atlantic subtropical high-pressure system. Without attention to these facts the seasonal distribution of rainfall in Spain and Portugal cannot be interpreted since it is more complex than in Italy, where the summer rainfall decreases steadily southwards. The coastal regions of the Iberian peninsula experience Mediterranean winter rains and also, except the north-west, Mediterranean summer drought; but in the more arid interior the tendency to winter rain is checked by the high-pressure system, and the tendency to summer drought is only slightly checked by local thunderstorms incidental to the shallow low-pressure system, so that spring and autumn, the only seasons when the Atlantic cyclonic depressions can move across Spain, have most rain.

Dr. Semmelhack regrets that his isothermal maps, especially the actual isotherms, are not free from error, but to this we may reply that isotherms never are accurate. Anomalies, for instance, are constantly indicating that Buchan's isotherms for the British Isles are in bad need of revision, having been drawn on much too few stations.

RAINFALL OF TURKEY

Since the war a network of new meteorological stations has been established by the Turkish Meteorological Office, and the data thus furnished are discussed cartographically by E. Reichel in *Ann. Hydrogr. Berl.*, Heft IX, 1932. The area dealt with is that of the new Turkey embracing a small portion of Thrace, Anatolia, and Armenia eastward to the vicinity of Lake Van and Mount Ararat. Most of the new stations only cover four years' observations, but by studying those in relation to a number of older stations with long records it has been found possible to produce a fairly reliable map showing the distribution of average rainfall. The distribution is governed by relief in relation to prevailing westerly winds and by distance from the sea. The coastal rim, except in the vicinity of European Turkey, is fairly wet, the stretch of heaviest rainfall, exceeding 80 inches a year, being on the Black Sea between Batum and Trebizond, though the Taurus Mountains and Anti-Taurus near the south coast have also a heavy fall of upwards of 60 inches. The largest dry area, with an annual fall well under 20 inches, occurs in the centre of the Anatolian tableland, but farther east where the highlands increase in altitude the general rainfall is greater in spite of remoteness from the sea.

The influence of the sea on the distribution of the rainfall is not a simple question of accessibility to supplies of moisture, but is enhanced by the tendency for the paths of the barometric depressions to keep out on the warm sea-water in winter, which is the rainy season, whereas in summer, when they might more readily penetrate inland, the Mediterranean circulation does not favour rain-producing depressions.

KARUN RIVER-GAUGING

We have received from the Irrigation Department of the Government of 'Iraq a typewritten pamphlet entitled 'Records of the River Karun.' This pamphlet places on permanent record a continuous series of gauge readings taken at Bandar Nasiri near Ahwaz on the lower Karun. The readings were recorded by Major

Adie from 1894–1905 on a gauge constructed by him. Another gauge was set up by Major Morton in 1905, and readings were recorded until a change was made to a third gauge at some unknown date, which is now estimated to be 1 January 1918. It has been possible to equate these three gauges, and it is now hoped that all the readings given are consistent, and referred to a single datum. There is thus available a continuous record from 1894 to the present (though some of the earlier readings are estimated), checked to some extent by discharge observations. This is important for the study of the hydrology of 'Iraq as, apart from the importance of the Karun in the Tigris–Euphrates system, the existing readings for the other eastern tributaries can now be supplemented.

LAKE STUDIES IN DUTCH EAST INDIES

During 1928–29 a German limnological expedition was at work in the Dutch East Indies. A brief account of the expedition, and the preliminary results, are given by F. Ruttner in the *Mitteilungen* of the Vienna Geographical Society (vol. 75, 1932, pp. 114–146). Most of the important lakes in Java and Sumatra were examined, but more especially the numerous small lakes in Eastern Java, and, in contrast, the largest lake, Toba, in Northern Sumatra. Much of the paper is given up to an account of the temperature and bio-chemical results, which were important, for few tropical lakes have been examined by modern methods. The paper however also contains a concise description of Toba lake, and a summary of the latest theories of its origin, checked by the researches of the expedition. The lake lies, in an area of subsidence, and among volcanoes, within a bow of the northern Barisan mountains. The approach from Sibolga in the south is across a flat plateau rising to the north, and, in contrast to the tropical luxuriance of adjacent areas, bare of vegetation. The plateau ends sharply, with a sudden drop of 500 metres to the level of the lake. The greatest depth of the lake yet sounded is 450 metres. The level outlines of the plateau, largely tufas with quartz intrusions, are broken by volcanic cones; in the vicinity also are found the tertiary rocks of the Barisan mountains. A feature of the lake is the large peninsula of Samosir, which almost divides it into two basins. This great difference of 1000 metres in level in the ancient mountain range is explained thus: As a result of late tertiary volcanic activity, when the tufa was erupted, a great section of the range collapsed. The lake which formed in the basin, from the evidence of terraces still existing, lay at a much higher level. Renewed activity in the centre of the lake formed the peninsulas of Samosir and Sibaulangit. Continued erosion has lowered the lake-level, and formed the plains at the south-eastern end. From the study of the characteristics of the three varieties of the Toba sediment, some of which have been found at a height of 460–500 metres above present lake-level, above the tufa, the writer shows that the lake is older than its present basin.

THE WAKWAK ISLANDS OF THE ARAB GEOGRAPHERS

The constant mention by the Arab geographers of islands bearing this name, on the outskirts of the then known world, has aroused a good deal of attention, and contradictory views have been held by commentators. The French orientalist, M. Gabriel Ferrand, has lately returned to the subject (which he had first discussed over a quarter of a century ago) in the *Journal Asiatique*, 1932, no. 2. He examines at great length, with perhaps rather unnecessary repetition, the references to such islands in all the important Arab sources, and on this basis arrives at what appears to be a reasonable conclusion. In his paper printed in the *Journal Asiatique* in 1904 (see *Journal*, vol. 25, p. 98), M. Ferrand had maintained that the Arab accounts referred, under the name Wakwak, to two distinct

regions, an eastern and a western, the western representing probably Madagascar (with possibly a part of the African coast), while he then followed De Goeje in placing the eastern in Japan, He has since reconsidered the second part of the question, and devotes a large part of the present paper—after repeating his arguments as to the western Wakwak—to a refutation of the idea that the eastern Wakwak was Japan. His main points are (1) that the indications of position given by the Arab writers, which he groups under ten heads, are nearly all inconsistent with De Goeje's view; (2) that Japanese history is silent as to any such commercial relations as are said to have been maintained in early days between Wakwak and the far south, extending even to East Africa. He finally fixes on Sumatra as the true site, and as he had been able to connect the western Wakwak with Malagasy roots, so he finds the origin of the eastern in the Pakpak (Arabicized as Fakfak) tribe of Sumatra. The duplication may, he thinks, have arisen in part from the legend of the marvellous tree, bearing fruit in human form and emitting a sound resembling the name, which is associated with both the regions in question and which M. Ferrand considers to have referred to the Pandanus. While the linguistic argument must surely be received with caution, there seems certainly good reason for placing the eastern Wakwak somewhere among the islands of South-East Asia.

UNDERGROUND EXPLORATION IN INDIANA

A considerable area in the Middle Mississippi Valley region consists of nearly horizontal limestones which present the typical features of the karst, with a well-developed underground drainage system. In Orange County, Indiana, the drainage basin of "Lost River" is an excellent illustration of the features of a karst region, sink-holes being present in very large numbers, together with disappearing streams and dry river-channels. The underground topography of a part of this, hitherto largely unknown, has lately been explored by Mr. Clyde A. Malott, of Indiana University, who has sent us the reprint of a paper on the subject from the *Proceedings of the Indiana Academy of Science*, vol. 41, pp. 285–316, illustrated by a map compiled by himself. Lost River begins as a normal over-ground stream, but after entering what is termed the sink-hole plain in a westward course of 12 miles, becomes engulfed in the neighbourhood of Orleans. Five miles farther west there is an elongated steep-sided depression, known as the Wesley Chapel Gulf (gulf being the general local term for such flat-bottomed hollows in the limestone) where the river comes temporarily to the surface at the foot of the cliff, afterwards taking a further course underground, which is accessible by a manhole-like opening. This is the part explored by Mr. Malott, who describes in detail the complicated network of channels discovered, and discusses certain phases in the development both of the gulf and the underground course of the river. It is calculated that the gulf represents the destruction and removal of 720,000 cubic yards of native limestone, the void having been partially filled, to a depth of 30 feet, by the deposition of alluvial silt. The outline of the gulf is very symmetrical, the length being approximately three times the width. Its long axis conforms to the direction of a major joint system in the rocks, and it seems to have originated in successive collapses due to the broadening of former underground channels. The existing channels follow courses determined by two intersecting joint systems, and are generally wide relatively to their height. They run at three different levels. The underground waters are chiefly those which have invaded the system from the surface, a long stretch of which has been completely deserted.

THE "BAYS" ON THE COASTAL PLAIN OF SOUTH AND NORTH CAROLINA

Shallow depressions, often containing water, occur in large numbers (more than 1500) over an area of some 10,000 square miles on the Atlantic coastal plain, and are known locally as "bays." Their origin was first discussed by L. C. Glenn in 1895 (*Science*, New York, new ser., vol. 2, pp. 472–475), who suggested that the valleys of small streams on a rising shore-line had been blocked by sand-bars. Laurence L. Smith (*Journ. Geol.*, Chicago, 1931, vol. 39, pp. 641–652), from the evidence of chemical analyses of material from borings made in the centre and at the rims of the depressions, suggested that they were formed by the leaching out of iron oxide and alumina from the sands and clays by the action of humic acids. Recently the question has been again raised by F. A. Melton and W. Schriever in a paper read in December 1932 before the American Association for the Advancement of Science and published in the *Journal of Geology* (Chicago, 1933, vol. 41, pp. 52–66). On an aerial map of about 500 square miles in Horry County, South Carolina, made by the Fairchild Aerial Surveys of New York, these depressions show up prominently, and the relations between them can be studied more clearly. Viewed on the ground they are not very conspicuous, except when filled with water, and they have been mostly missed by the topographical surveyors. As shown on the aerial photographs they have smooth and regular elliptical outlines, with average dimensions of 2200 and 1400 feet along the major and minor axes. The largest measures 8090 by 4410 feet, and many are less than 500 feet across. A curious feature is that the major axes of the ellipses are all parallel to the north-west to south-east direction. Further, the ellipticity varies with the size of the depressions, being greater in the larger ones, while smaller ones are more nearly circular in outline; $(a-b)/a$ ranging from 0·454 to 0·174 with an average of 0·336. Some of the depressions are surrounded by an elevated rim, which, when complete, is higher at the south-east end of the ellipse. Partial rims are shown only at the south-east ends. Occasionally there may be double or triple concentric rims close together. There is overlapping of the depressions in some cases, and occasionally a smaller depression is seen inside a larger one. The rims consist of loose sand and have very gentle slopes: in one of the larger depressions the rim is 5 feet high and 250 feet wide. The depressions have been partly filled up by the growth of peat; depths below this are 25 to 50 feet in depressions ¼ to ½ mile across.

To account for the origin of these depressions various geological agents are discussed—waves, shore currents, wind, solution, volcanicity, glaciation, and submarine scour; but none of these affords a satisfactory explanation. The suggestion is made that they were formed by a large globular cluster of meteorites (perhaps 400 miles in diameter and rashly compared with a comet—an idea that has appealed to the newspapers) striking the Earth from the north-west at an angle of 35° to 55°. No trace of meteoritic material has been found around these "scars," and no comparison is made with authenticated meteorite craters, from which indeed they show many points of difference. The difference in ellipticity is accounted for by the smaller masses being more retarded by the resistance of the Earth's atmosphere and consequently falling at a steeper angle. If this were the case then the smaller and rounder depressions should lie to the north-west rather than being intermingled with the larger ones. In the case of observed showers of meteoric stones the largest masses carry farthest. L. J. S.

A PTOLEMY MS. OF THE EARLY SIXTEENTH CENTURY

A hitherto unknown Ptolemy MS. (maps only) has lately come into the hands of a well-known German firm, and has been described by Professor Josef Fischer

in the *Schweizer Gutenbergmuseum*, no. 4, 1932. Although its comparatively late date robs it of the importance of MSS. written before the Geography appeared in print, it offers one or two interesting problems, particularly in connection with the personality of its unknown author. His signature on the MS. runs "Georgius Schbab Neapolitanus Stirus Me faccebat" (*sic*), and though the third word would at first sight be taken to refer to Naples, there is absolutely nothing in the work pointing to any connection with Italy. The singular spelling of the surname gives a clue to the draughtsman's nationality. The form Schwab would at once suggest a German, and Professor Fischer finds that in early South German writing *b* did frequently take the place of *w*. "Neapolitanus" is thus probably the latinized designation of a man hailing from one of the many German towns bearing the name Neustadt, yet the addition of Stirus indicates that he was a native of Styria, where the same dialectic forms did prevail as in Southern Bavaria and where there is a place *Neumarkt*. Coming to the content of the document, Professor Fischer finds that the world-map shows close agreement with that in the "Margarita Philosophica" of 1503, while the special maps reproduce features found in the Ulm Ptolemies of 1482 and 1486, and especially in the Strassburg edition of 1513, which no doubt supplied the immediate pattern. But there are one or two original features, such as the insertion of *Troia* and *Holandia*, not found in any other version of Ptolemy's maps. As the world-map is drawn on different paper from the rest, and has a different source, it is probably earlier in date.

JUTE

The production of raw jute and the present position of the jute industry is described by Dr. F. Bonsack in the fourth volume of a new series entitled 'Bücherei der Faserforschung' (Leipzig: S. Hirzel). The cultivation of jute is practically confined to the south-west monsoonal area of Bengal and neighbouring districts of Bihar, Orissa, and Assam; but even within this area the yield varies considerably, mainly in relation with the rainfall, temperature, and soil.

About 7 per cent. of the cultivated area of Bengal was devoted to jute in 1923–24, but this figure varies considerably from year to year in accordance with market prospects. The dominance of Bengal is shown by the fact that the districts of Maimansingh, Tippera, Dacca, and Rangpur alone contain about 50 per cent. of the area cultivated for jute in India.

Of the jute produced in India, about 50 per cent. is consumed internally (1913–14, 50 per cent.; 1923–24, 40 per cent.), Great Britain and Germany being the chief customers for the exports. Attempts to grow jute outside India have met with most success in Formosa. Dr. Bonsack concludes by discussing the jute industry in the various countries, and the uses to which jute is put. The latest statistics used are usually for 1924, when the industry had not yet reached pre-war averages. An important product—jute sacks—is dependent upon the prosperity of many forms of world agriculture and industry.

A NEW GERMAN PERIODICAL

We have received from the editor, Dr. Irmfried Siedentop, the parts already issued of a new German periodical, *Geographische Wochenschrift*. It is published at Halle, and is to appear at least three times a month. The aim is to provide short articles, containing facts rather than opinions, on current geographical subjects, and in this connection, the advantage of its frequent appearance is emphasized. As it is designed largely for use by teachers, educational theory and practice forms the subject of several articles in the numbers which have already appeared, but others deal with physical, economic, and political geography, and

exploration. Each number contains a meteorological report, as well as geographical notes and reviews. The periodical has confined itself so far to German subjects and literature, but its value to those interested in geographical progress in Germany should be considerable. The annual subscription is M.9.60, plus postage.

MEETINGS: SESSION 1932–1933

Ninth Evening Meeting, 6 March 1933. The President in the Chair

Elections: Horace Francis Bath; Chunilal Becharlal Bhatt, B.A., B.T.; Harihar Chakraabarti, M.A., B.ED.; Geoffrey Marsden Chapman; Francis C. Chichester; John Ashhurst Coplestone; John Corbett-Jones; George Brownell Nathaniel Creswick; The Rev. Edward John George Forse; Miss Maureen Geoghegan; Lieut.-Col. Joscelyn Theodore Horsburg Lane, O.B.E., M.C.; Thomas H. Manning; J. J. Mitchell, M.A.; Miss Muriel Mary Patchell; Horatio Sandford; Alfred Stokes, J.P.; Patrick Millington Synge; Hugh Tevis.

Paper: Kerguelen. By Sir Douglas Mawson

Fifth Afternoon Meeting, 13 March 1933. The President in the Chair

Paper: The Physiography of South Haven Peninsula, Studland Heath, Dorset. By Captain C. R. P. Diver

Tenth Evening Meeting, 20 March 1933. The President in the Chair

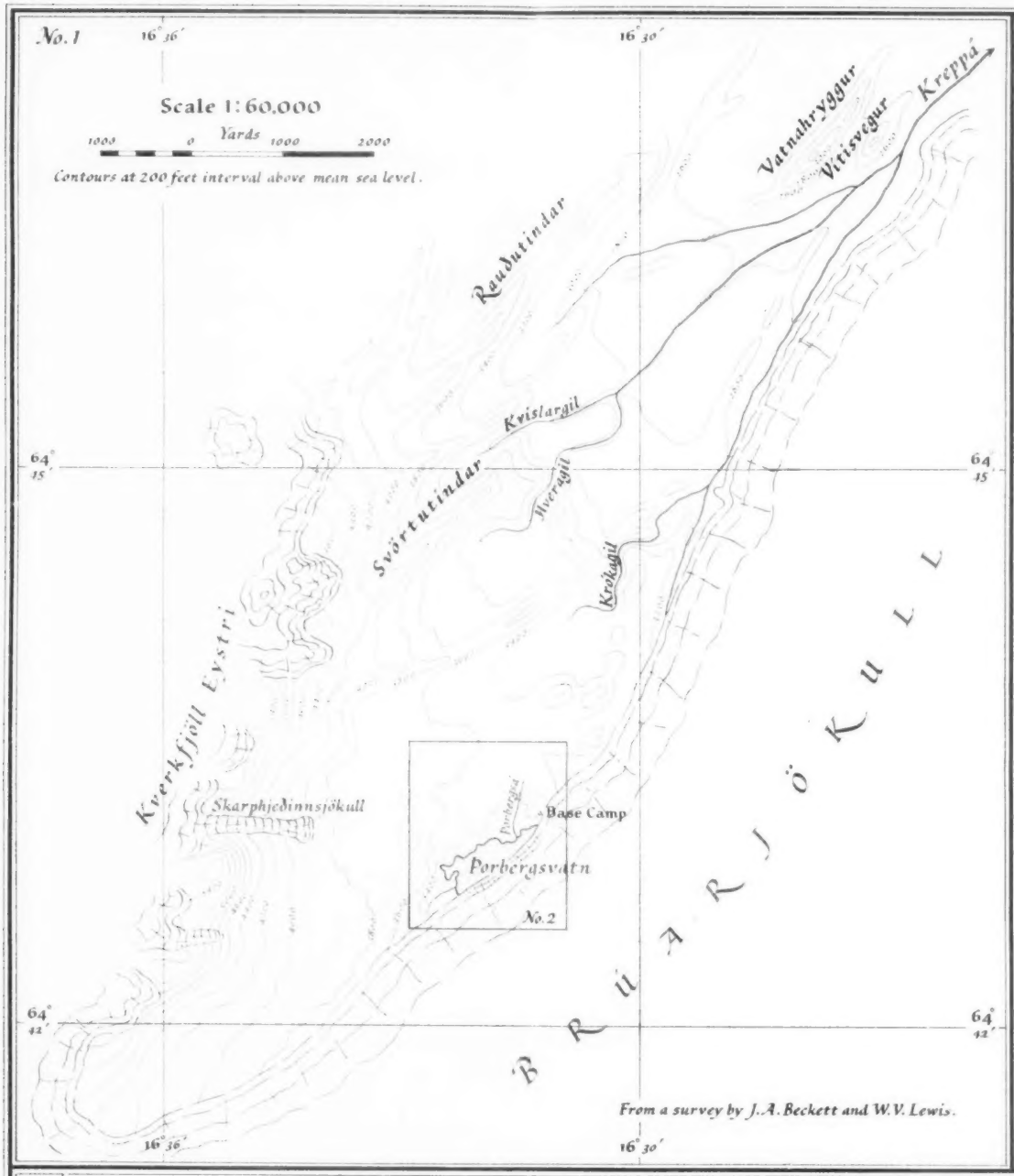
Elections: Robert Percy Beckinsale, B.A.; Albert Edward Blackburn; Alec William Broers; Louis Cahen; Colonel Sir William Houghton Gastrell, C.M.G.; Mrs. Constance Rosalie Catherine Handley; Leonard Hassall, B.SC.; Thomas Morris Keeling; Captain Frank Edward Lane.

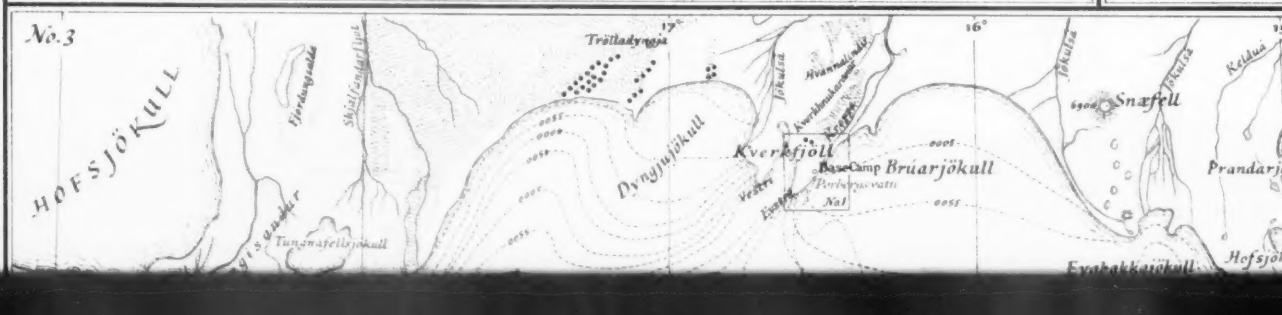
Paper: Some Contrasts in the Civilizations of Indo-China. By M. Jean Delacour

Maps to illustrate the paper o

THE CAMBRIDGE EXPEDITION TO

by Brian B. Roberts.





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TO VATNAJÖKULL, 1932.

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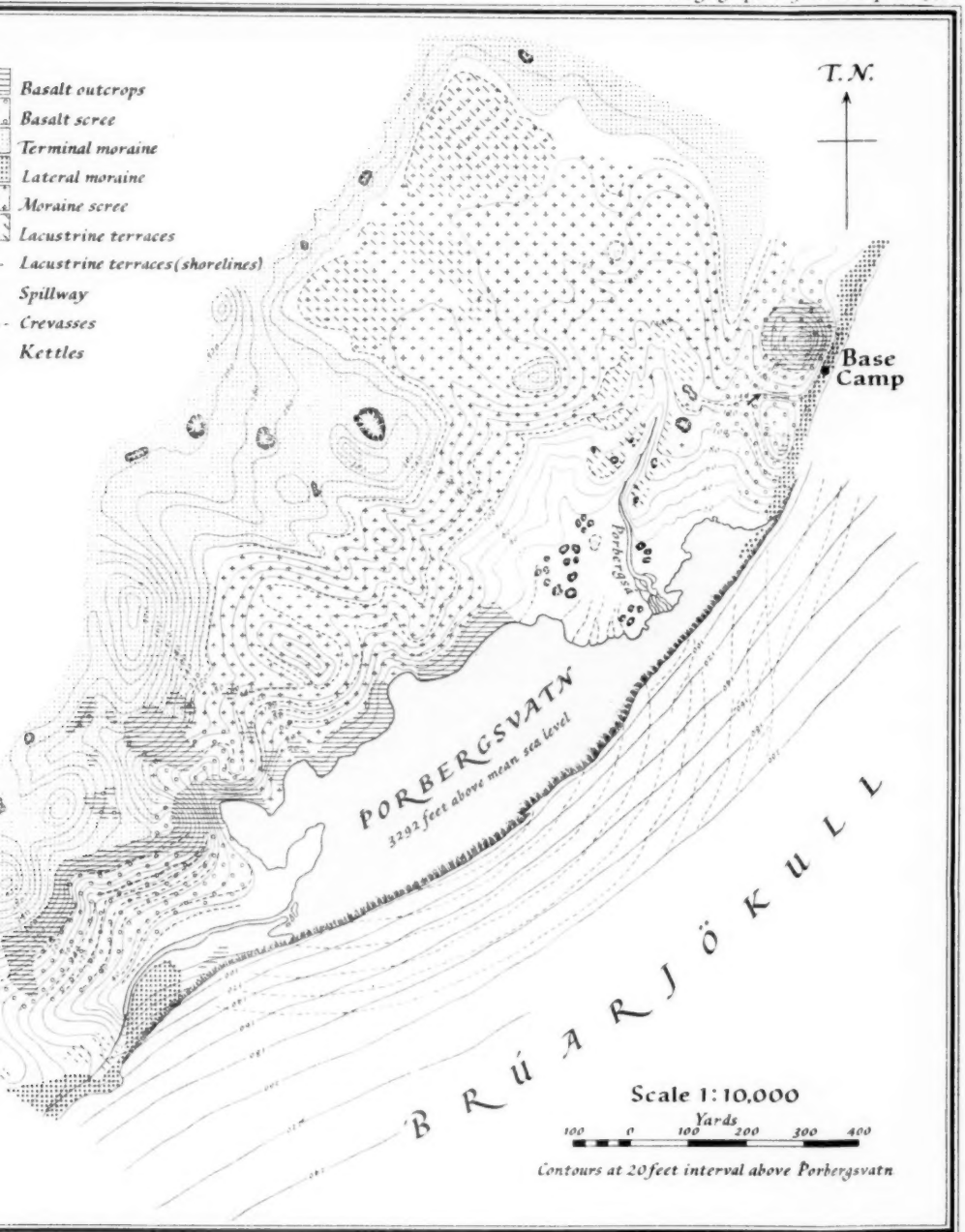
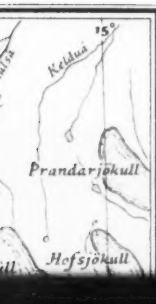
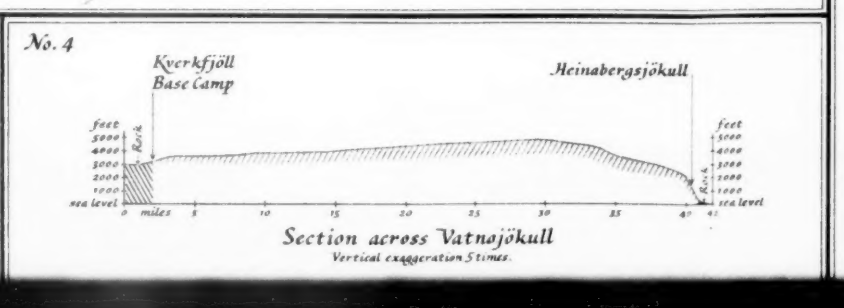
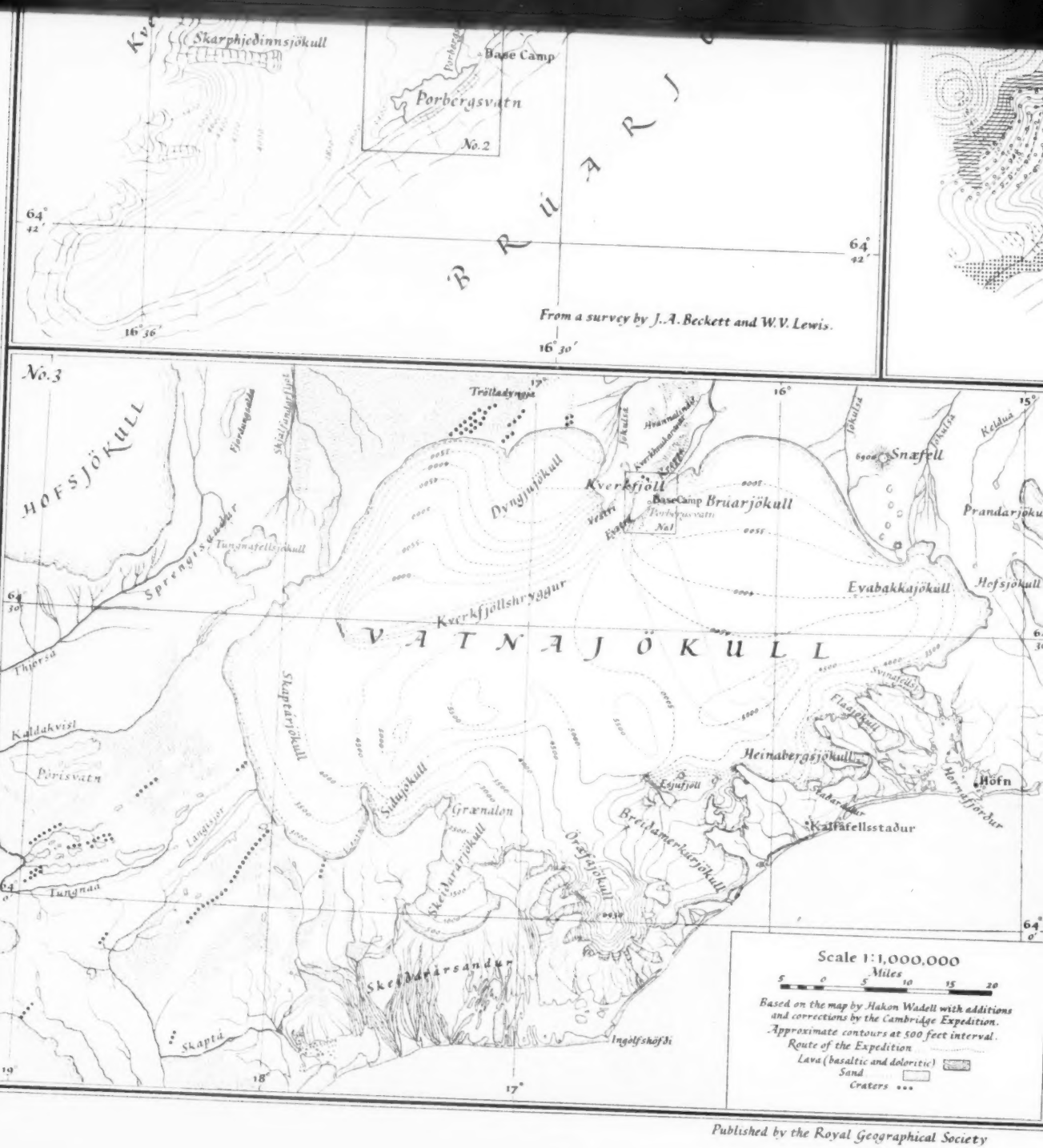
The Geographical Journal, April, 1933.

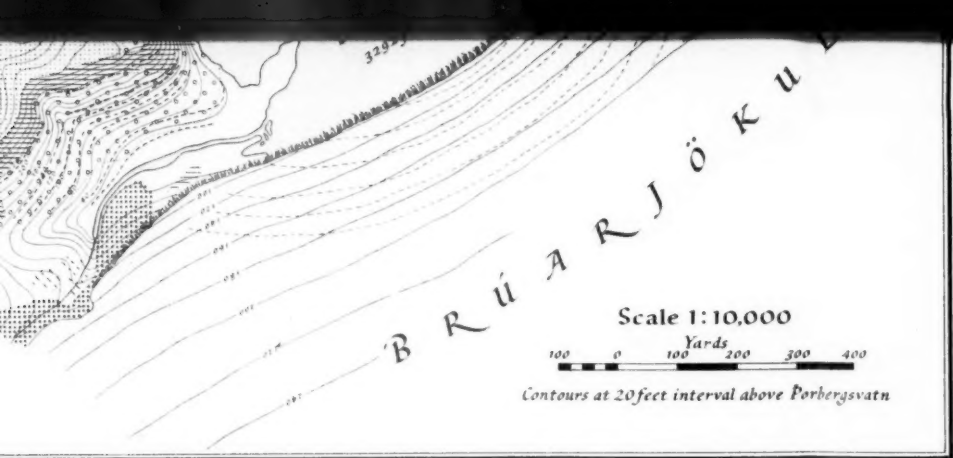








Published by the Royal Geographical Society



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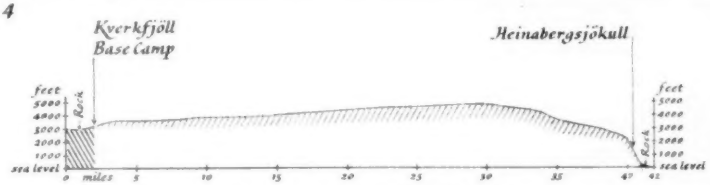

Section across Vatnajökull
Vertical exaggeration 5 times.

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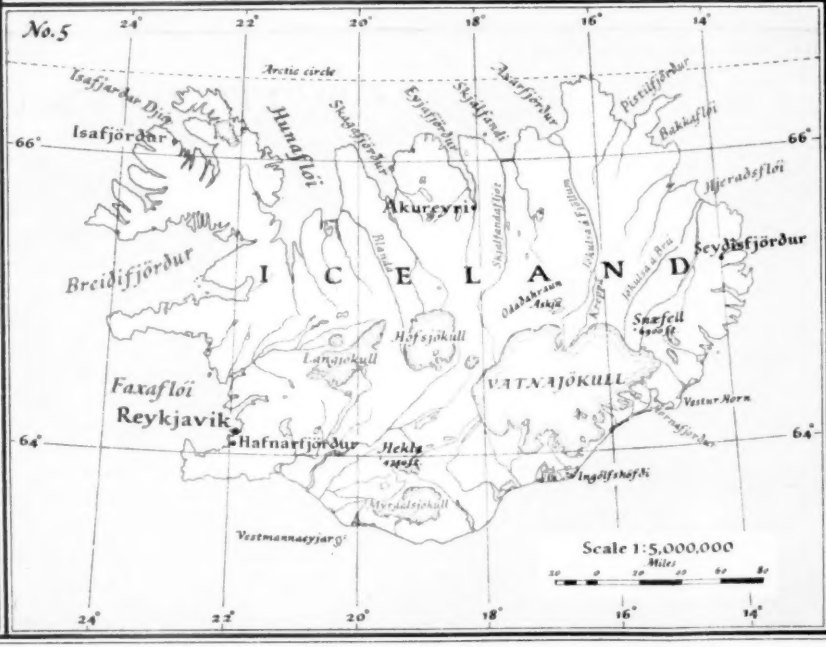

Society

VATNAJÖKULL
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